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ON SARCOMA OF THE MUSCLES AND THE CONNECTIVE-TISSUE SPACES OF THE LIMBS

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THIS paper was suggested by a short communication which was contributed by the writer to a Discussion at the French Society of Surgery in October, 1938, on "Sarcomes des Muscles et des Coulées conjonctives des Membres". To the President and the Council of this Society all surgeons are under a special obligation for their selection of this subject for debate, since clinical records and museum specimens illustrating surgical activities in dealing with such cases are neither multitudinous in number nor commonplace in character. Of special excellence on the occasion of that Congress was the introductory address of Pierre Moulonguet and Eugene Pollosson,[1] which will remain one of the most distinguished contributions to our knowledge of the subject yet made; and a month or two later there appeared another comprehensive article upon these infrequent tumours from the pen of Gunnar Jönsson[2] from the Radiumhemmet, Stockholm.

The comparative infrequency of the condition may be discerned by the fact that throughout my surgical career I have myself treated only 20 of these cases and have seen only 9 others in consultation. Furthermore the reports of my Hospital, both surgical and radiotherapeutic, show that only another 43 cases are available for this discussion—a total of a mere 72 cases for personal review.

Moreover, frequent journeyings throughout Great Britain for the purpose of visiting the museums of the teaching hospitals in London, in England, and in Scotland have only brought to light an insignificant number of specimens arranged for the study of students, undergraduate and post-graduate, although doubtless only those specimens which are of large size or of exquisite preparation may justify their inclusion in a museum; new growths of muscle which have attained dimensions necessitating wide excision or the amputation of the limb are those which alone are likely to find a place as pathological curiosities. Inquiry also in departments of pathological histology reveals the fact that tumours of muscles of the limb sent from outside sources for expert pathological opinion, are extremely rare.

The condition then is not a frequent one, and fully merited the consideration of the surgeons of the French Society of Surgery at their meeting in 1938.

Relative Frequency Among Tumours of Limbs.—These cases are far less frequent than skeletal sarcomata, and Moulonguet and Pollosson quote the statistics of Neck, who between 1904 and 1926 dealt with 67 sarcomata of the limbs, of which 47 were osteosarcomata and only 20 involved the soft tissues.

The Existence of Malignant Tumours of Muscle of Myogenic Origin.—There have been some who held the view that there are no true tumours of muscle, but that these arise from the connective tissue in and around the muscle-fibres. The histological characters of the rhabdomyosarcomata afford incontestible proof that primary malignant tumours of muscle do in point of fact exist.

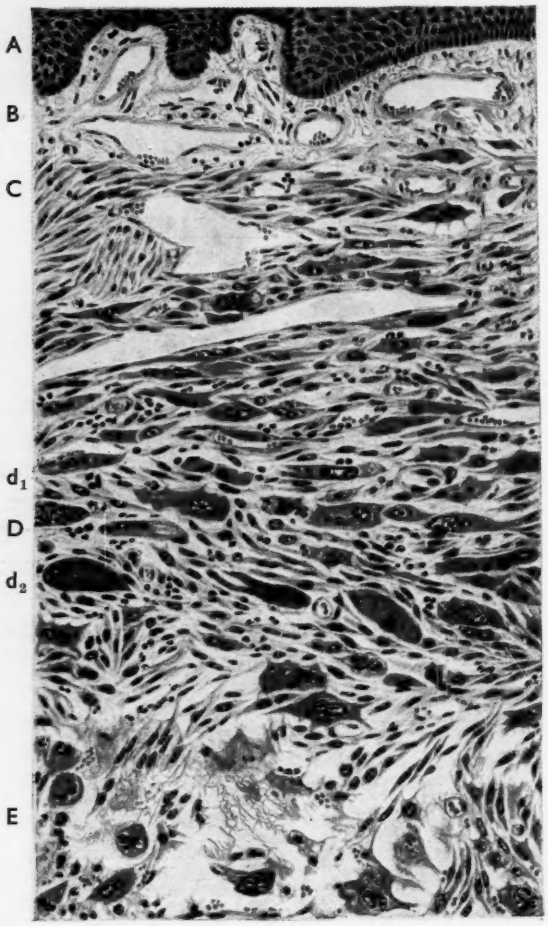

FIG. 1.—Microscopical section of a rhabdomyosarcoma with overlying skin. A, Surface epithelium, skin of flank, lateral to fungating area; B, Telangiectatic area, dermis, superficial to tumour; C, Area of spindle cell, less differentiated myoblasts, without striation; d_1, In centre, one of the rare cell forms, with cross-striation and large single nucleus; D, Typical tumour area, with large myoblasts, showing occasional mitosis and one or several nuclei—longitudinal striation a frequent finding; d_2, In centre, another cell with cross-striation and four nuclei; E, Area with degenerative changes, deeper in tumour. (*Kindly prepared for me and drawn by Dr. E. K. Dawson, Research Laboratories, Royal College of Physicians, Edinburgh.*)

D. F. Cappell and G. L. Montgomery[3] regard tumours of striated-muscle origin as divisible into two groups, according as well-defined cross-striation is demonstrable or not in the cells: (*a*) rhabdomyomata are tumours in which a proportion of the cells exhibit unequivocal longitudinal and transverse striation; and (*b*) myoblastomata are neoplasms whose cells morphologically and tinctorially resemble skeletal-muscle cells, but which exhibit no transverse striation. Moreover, each group may be simple or malignant in its characters.

Cappell and Montgomery believe that the real malignancy of the tumours depends not upon the dissemination of large myoblasts and striped fibres by lymphatic embolism or permeation, but upon the existence of truly primitive or highly anaplastic round and spindle cells which are readily carried to distant portions of the body and differentiate after implantation in their new sites.

Transverse striation is never a conspicuous phenomenon in the cells of myosarcomata arising in the skeletal muscles, thereby contrasting with some of the teratomata or mixed-cell tumours, where it is often a most obvious histological feature. Demonstration of transverse striation in many of the rhabdomyosarcomata often requires the most skilled and careful histological methods.

Dr. E. K. Dawson has prepared and painted for me this beautiful picture (*Fig.* 1) of a rhabdomyosarcoma which demonstrates the different types of cell that may be found in the rhabdomyosarcoma of skeletal muscle. In the most

superficial layers are to be seen spindle cells and less differentiated myoblasts without striation. There are also to be seen large myoblasts with longitudinal striation and several cells with cross or transverse striation. Proof of the myogenic origin of certain forms of muscle sarcoma is thus incontrovertible.

Age Incidence.—Every age is liable to the development of these tumours; an investigation of my own material reveals no special liability of any decade, although the malady in our experience seems to have been rather more frequent at ages in the neighbourhood of 20, 40, and 70 years.

Moulonguet and Pollosson remark on the relative immunity of the young, and curiously in their collected cases there was only one example of a muscle sarcoma in the second decade. They record several cases in very young infants, for example at 2½ months (Mouchet) and at 4½ months (Bérard). In Mouchet's case of sarcoma the mother had actually noticed a swelling from the second day after birth, thereby suggesting a congenital origin.

Specimens of sarcomata of the limb muscles in the very young are not wanting in our museums, and striking examples may be seen in the surgical museums of Liverpool University (*Fig.* 2), and Guy's, Westminster, and St. Thomas's Hospitals.

The material of the Radiumhemmet affords the information that in cases over 40 years of age rhabdomyosarcoma is three times as common as the other histological varieties, but under 40 the other neoplasms are four times as frequent as rhabdomyosarcoma. It must be remembered, however, that this latter form of malignant tumour appears to be more common in the French statistics and preponderatingly so in the Scandinavian figures when compared with our own British experience.

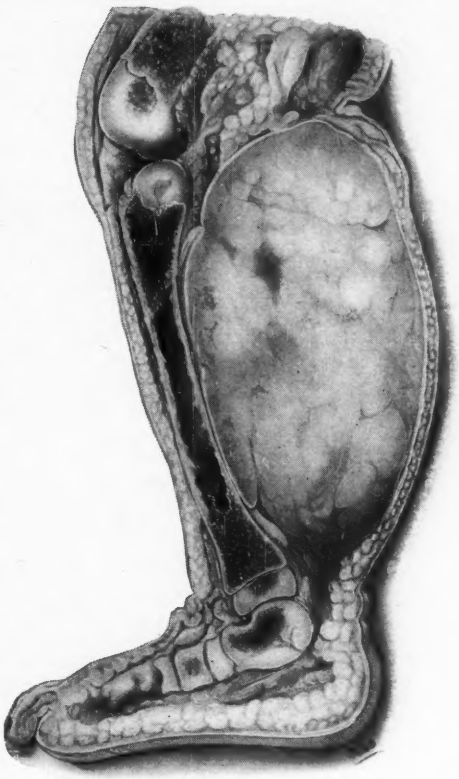

FIG. 2.—Sarcoma of calf muscles of infant. (*Thompson Yates Laboratory Museum, University of Liverpool.*)

Sex Incidence.—In my material and in the figures collected by Moulonguet and Pollosson, there is no difference in the liability of the sexes, but in the material from the Radiumhemmet males were attacked more frequently than women in the ratio of 3 : 2.

Injury as Aetiological Factor.—The role played by injury in the determination of malignant tumours has often been debated, and is too large a subject for discussion here. Thiem and Bramann[4] lay down the following conditions which must be fulfilled before a causal relationship can be definitely established: (1) The accident impugned must be single, definite, and limited in duration. (2) The injury must be of considerable severity. (3) There must be a

FIG. 3.—Sarcoma of extensor muscles of forearm consequent upon injury with a cricket ball. (*Guy's Hospital Museum, No.* 4731.)

FIG. 4.—A fungating mixed-cell fibroblastic tumour or rhabdomyosarcoma of the muscles of the lateral aspect of the left forearm. There is no connexion with the bone. Alleged bite. Amputation. Death five months later. (*Museum of Royal College of Surgeons, Edinburgh,* 5 (7) b. 8.)

topographical relation between the injury and the tumour. (4) There should also be a time relationship, which may vary from 3 weeks to 2 years.

Two of the illustrations (*Figs.* 3, 4) depict tumours of which the origin was ascribed to injury: one belonged to a patient who had been struck by a cricket ball on the forearm, and who was subsequently operated upon in Guy's Hospital for a sarcoma in the region struck; and a more doubtful causal relation may be found in a specimen from the Museum of the Royal College of Surgeons of Edinburgh, in which the development of the tumour was attributed by the patient to a bite! A sarcoma of the gastrocnemius muscle in a patient of my friend and colleague, Mr. Sampson Handley, developed some years after an injury to that muscle from a penknife.

I operated upon a man wounded in the last European War where a sarcoma of the pectoralis major followed a gunshot injury of that muscle; this relationship of injury to tumour was admitted by a Pensions Board.

Moulonguet and Pollosson also mention a case in which a causal connexion was recognized by an insurance company, a fibroblastic sarcoma having developed on the external aspect of the arm after this region had been injured by a blow from a cow's horn two months before.

Topography of Sarcomata of the Muscle and Connective Tissues of the Limbs.—There can be little doubt from a perusal of the literature that the lower limb is more frequently affected by the malady than is the upper extremity. Among 109 cases of muscle sarcoma investigated by Lorenz from the literature, more than 50 per cent of the tumours were situated in the thigh or upper arm, and more than one-third of all the cases were located in the thigh. The spinati are frequently the site of origin of a sarcoma; in several cases of my own the prognosis in this region has been good, and several patients have survived for many years. *Fig.* 5 comes from a patient of Mr. Harry Platt, of Manchester, and Mr. Cecil Wakeley published another in a recent number of THE BRITISH JOURNAL OF SURGERY.

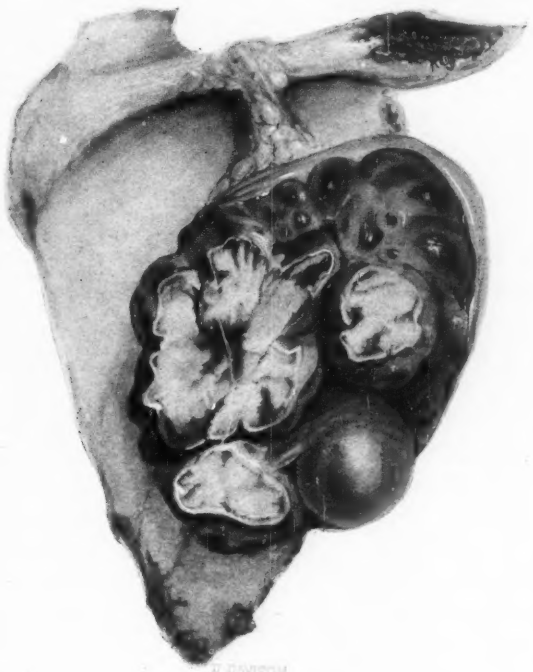

FIG. 5.—Spindle-celled sarcoma of the infraspinatus, from a patient of Mr. Harry Platt. (*From the Pathological Department, University of Manchester.*)

FIG. 6.—A spindle-celled sarcoma of the rectus femoris and vastus medialis of the right thigh. This patient was unsuccessfully treated by repeated local excision and radium implantation. Finally amputation was performed a little over 2½ years from the beginning of the tumour. Rapid fatal ending. (*Middlesex Hospital Museum*, V.5.)

FIG. 8.—Sarcoma of the extensor muscles of the forearm. (*St. Mary's Hospital Museum*, 84. 762².)

FIG. 7.—Spindle-celled sarcoma of the triceps. The history is curious: originally there arose a lymphosarcoma of the left tonsil; subsequently a tumour of glands in the left side of the neck, which was also reported as lymphosarcoma. Next appeared the tumour in the left triceps, which was first radiated and an amputation was subsequently performed. Finally glands appeared on the right side of the neck which are also lymphosarcomatous. (*By courtesy of Mr. H. F. Woolfenden and Professor Thomas B. Davie, University of Liverpool.*)

Sarcomata have a predilection not only for certain segments of the limb, but even for certain muscles. Most surgeons will agree with Durante, who emphasizes the special vulnerability of the rectus femoris (*Fig.* 6), the triceps of the arm (*Fig.* 7), the muscles of the lower leg (especially the gastrocnemius), the muscles of the forearm (*Fig.* 8), the pectoralis major, the deltoid, and the glutei, but that author made no mention of the adductors of the thigh, which in point of fact are a very frequent site of the malady. A scrutiny, however, of one's personal material and the 'Middlesex' series, and an inspection of the museums of most of the teaching hospitals in England and Scotland, convince me that almost every muscle in the upper and lower limb is liable to be the seat of a sarcoma (*Fig.* 9).

FIG. 9.—Spindle-cell sarcoma of the sartorius. (*Museum of the Bristol General Hospital.*)

CLINICAL ASPECTS

In most patients sarcoma of the muscles or the connective-tissue planes of the limbs first betrays its existence in the form of a painless localized swelling. The absence of pain, the mental hebetude of the average patient in respect of a lump which does not interfere with his normal activities, or the fear of an unpalatable surgical opinion, tends to keep operator and victim apart until the tumour has sometimes attained a considerable size; yet in these days of semi-nudism sarcomata of the muscles of the limbs are scarcely likely to attain the monstrous dimensions of former decades. The tumour may be discovered accidentally on examination for the results of some injury, perhaps trifling in nature, or there may be some slight impairment of function of a limb.

On occasion pain may be of even a severity akin to toothache, and pain is said to have been " unbearable " in one case. Characteristically, however, the tumours are painless, and when pain is complained of, the implication is that the neoplasm has already extended farther than seemed probable, and is already compressing adjacent nerve structures.

The painlessness of the tumour which has already been emphasized results in the primary detection of the lump under circumstances which vary from droll to tragic, and which include even in my own experience the horrified surprise of a playmate at a public bathing pool, the critical gaze of an onlooker at a seaside plage, and the playful, if wayward, touch of a passionate paramour. When pain does occur as an initial symptom it is less rare according to Gunnar Jönsson in the rhabdomyosarcomata and spindle-cell sarcomata; thus in only 9 of the 60 cases analysed by this writer was pain the first symptom noted, yet of these 6 were rhabdomyosarcomata.

The complete or almost complete absence of functional disturbance may afford a most remarkable contrast to the volume of the tumour, and unfortunately may engender hesitation on the part of the patient to seek early relief. In the early stages the tumour is single, rounded, or ovoid, and usually deep-seated; when the musculature of the limb is relaxed the lump can be moved in every direction.

Anatomical considerations may play some part in determining the mode of extension and spread of a sarcoma of the limb-musculature and of the connective-tissue planes of the extremity (*Fig.* 10). In respect of the former variety there is less tendency for the growth to run rapid riot along the intermuscular planes. The distinction between the two groups is perhaps of academic rather than of clinical or therapeutic value, nor should the pathologico-anatomical classification into infiltrating and encapsuled forms be laboured too zealously, for these tumours have no true capsule and the abolition of the word encapsulation is better calculated to relegate the operation of so-called enucleation for these tumours into the background.

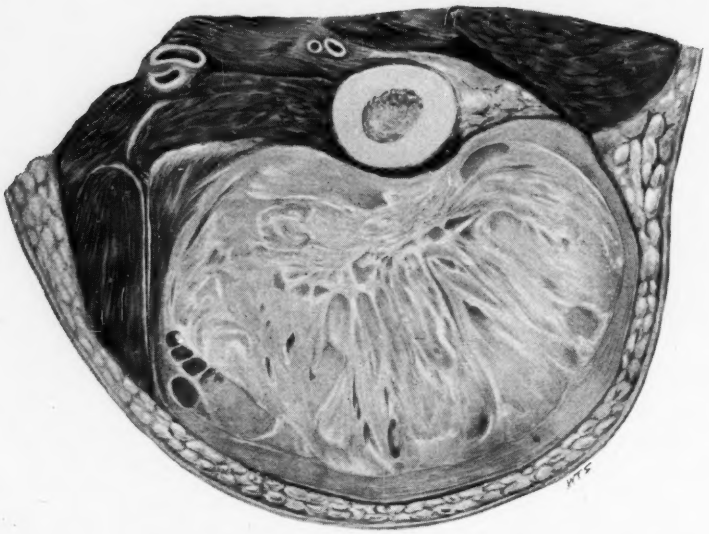

FIG. 10.—Specimen of myosarcoma involving the whole antero-lateral aspect of the thigh and almost completely replacing the quadriceps. A specimen of Mr. Sampson Handley's. (*Middlesex Hospital Museum*, A.59.1.)

The *clinical course* of these tumours may vary:—

1. The neoplasm may have grown for some weeks or months, and is then submitted to local removal; a conservative operation may thereafter be repeated once, twice, or on even more occasions, probably at decreasing intervals. Perhaps radiotherapy in some form is superadded, but death takes place in two or three years from the commencement.

2. In other cases the tumour may assume a hurricane type of growth and in a few months or even weeks may attain the size of an orange or a coco-nut. In this fulminating type death usually occurs within a year, whatever be the form of treatment, surgical or radiotherapeutic.

3. Sometimes the tumour may remain stationary or small for several years and then assume a rapid course; it has been said that the tumour "takes fire". The sudden change in the clinical course of a neoplasm may be determined by an injury or may be spontaneous. This evolution "en deux temps" is not characteristic of any special histological variety of tumour, although according to Moulonguet and Pollosson the phenomenon is more frequent in "les sarcomes fibroblastiques, lipoblastiques et ostéoblastiques".

The enormous tumours are uncommon nowadays, and those that are permitted to attain a gigantic size develop circulatory complications, and the resulting œdema, necrosis, ulceration, etc., gradually compass a fatal ending.

Metastases.—It is the experience of all surgeons that metastases in these cases are most frequent in the lungs, or at any rate in the thorax, although the pericardium is always said to escape. The skeletal structures are also prone to be attacked by secondary growths, especially the spine; more rarely the liver and the abdomen are implicated. Metastases, however, may appear anywhere, and Moulonguet and Pollosson record 2 cases of secondary growths in the breast. A metastasis in the occipital region of the scalp appeared three years after amputation for the spindle-celled sarcoma of the thigh shown in *Fig.* 11.

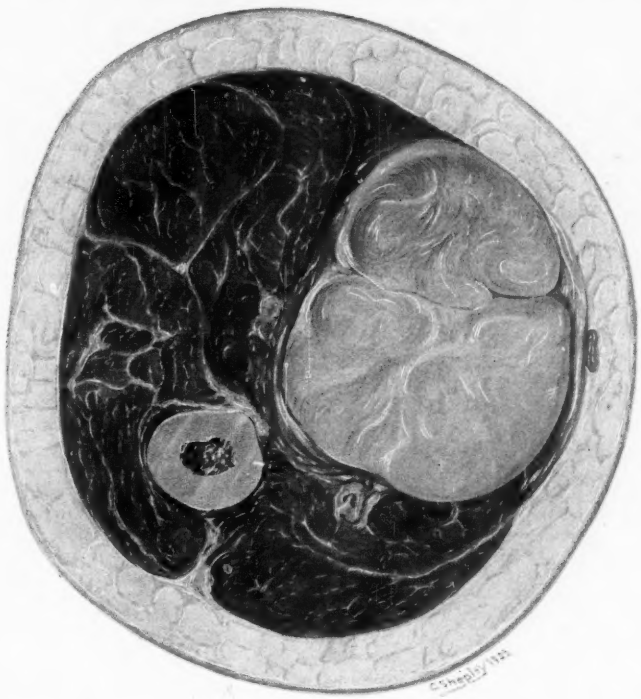

FIG. 11.—Spindle-cell sarcoma growing from connective-tissue planes of the thigh. Amputation. Death from metastasis three years later. (*From the Surgical Department of the University of Edinburgh*, V. (M). 2.)

DIAGNOSIS

A small text-book might almost be written upon the conditions which may simulate a sarcoma of the limb muscles or the connective-tissue planes of the extremities; the shelves of surgical museums with a praiseworthy honesty bear witness to mistakes that have been made. The repetition of the small and inadequate local operations also betrays a lack of appreciation of the latent malignant potentialities of many, if not most, of the connective-tissue tumours of the limbs.

Nevertheless Gunnar Jönsson writes that the pre-operative diagnosis was only wrong in 3 out of his series of 112 cases. If a tumour of the connective tissues and muscles of the limb be present, it is well to assume its malignancy, for the

malignant tumours are far more frequent than benign; the adoption of such an attitude will ensure early removal, and authoritative information of the histology will be forthcoming. The innate malignant tendencies have already been referred to; a specimen in the Pathological Museum, Westminster Hospital, No. 382B,

FIG. 12.—This tumour arose in the connective tissue of Hunter's canal; microscopically it was a myxosarcoma with ossification. The tumour was surrounded by a thin capsule within which is a narrow layer of bone completely encircling the growth. The cystic spaces have no definite lining and are due to cystic degeneration of myxomatous tissue. (*R.C.S. Museum*, 3216.3.)

shows a chronic intramuscular cyst of the thigh, containing calcium deposit, and at its lower pole there is a spindle-celled sarcoma (E. P. Brockman's case).

Even the lipoma may have sinister tendencies. Professor R. W. Alexander, of Dundee, gave me notes of such a case, which was reported upon by Professor Cappell: "The specimen is a lipoma in which the fat cells are somewhat smaller than in the usual simple type, and which contains areas of greater cellularity in which the cells are only beginning to accumulate fat. I am of the opinion that the tumour is of doubtful malignancy."

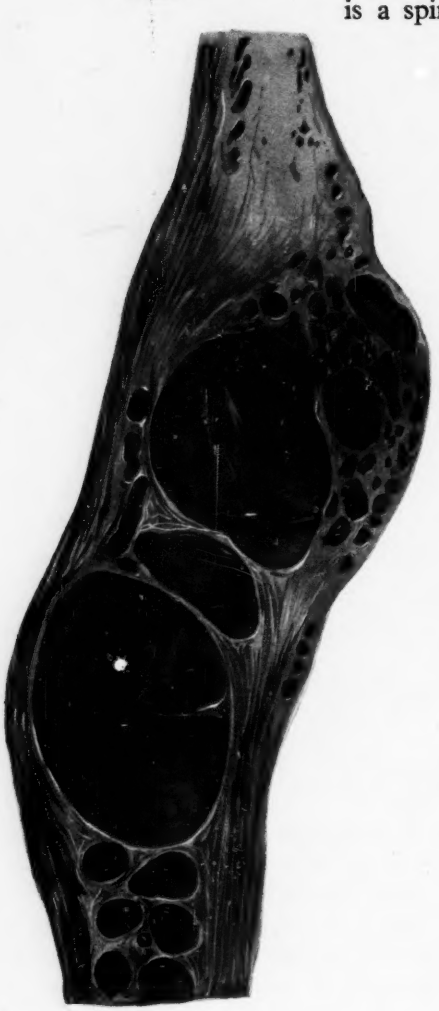

FIG. 13.—Depicting a cavernous angioma of the gracilis in a woman of 22 years which had been present for seven years and which was excised by the late Charles Stonham, 1900. (*R.C.S. Museum*, 1432.1.)

FIG. 14.—Secondary chorionepithelioma in the gastrocnemius; a large hæmorrhagic mass of growth. (*Museum, Pathological Department, University of Bristol*, L.E.2.)

Westminster Hospital Museum is particularly rich in specimens illustrating muscle pathology; thus No. 383A is a pure myxoma of the vastus internus which was removed by Mr. Rock Carling from a patient who was sufficiently well to climb in the Alps later.

A traumatic cyst may well simulate a more serious tumour. Specimen 382D in the Westminster Hospital is a thin-walled cyst covered with fat and attached to the muscles on the outer side of the leg; the patient had suffered a blow on the spot a few months earlier.

Radiology may be of value in the diagnosis of some muscular tumours of the limbs and may be of the greatest aid in excluding traumatic myositis ossificans and skeletal tumours; areas of calcification and even ossification may be found in muscle and fascial tumours, as shown in *Fig.* 12; in this case the tumour was a myxosarcoma. Razemon, Vandendorp, and Driessens[5] have recently drawn attention to what they term osteochondromatosis of muscle in a woman of 60. Radiology should furnish an incentive to surgical exploration.

Angioma (*Fig.* 13) may be more easy to diagnose; the tumour is unusual, but when present affects the young and is often situated in rather inaccessible regions of the limb. There is frequently severe pain, and the tumour increases in volume on effort.

It would be difficult to diagnose those tumours arising in connexion with nerves (neurofibromata) without actual exploration and removal of material.

The secondary chorionepitheliomatous mass in the gastrocnemius (*Fig.* 14) must indeed be one of the rarest of all malignant tumours in the muscles of the limbs.

FIG. 15.—Illustrating a rhabdomyosarcoma of the gracilis muscle. A local excision had been performed and recurrence rapidly took place, with fungation through the scar. Amputation at hip-joint. There is a cystic fusiform swelling 6 in. × 3 in. composed of growth and blood-clot. The patient died without recurrence from a cerebral hæmorrhage. (*Amputation by E. Grainger Muir, from Gordon-Taylor's Surgical Unit, Middlesex Hospital.*)

PROGNOSIS

The prognosis depends upon various circumstances and not least upon the histological character of the malignant tumour. All cases are serious, but most grave is the rhabdomyosarcoma. It has been said that all cases published have ended fatally, although a personal case of my own died two years after amputation of the hip-joint without recurrence (*Figs.* 15, 16).

Although the outlook in spindle-celled sarcoma is serious, it is not so desperate as in the previous group. The prognosis of fibrosarcoma is the best.

Repeated operations—possibly radiation—repeated recurrence, characterize the clinical course of the tumours under consideration, until the disease is haply checked by amputation or death ensues. Moulonguet and Pollosson mention the extreme

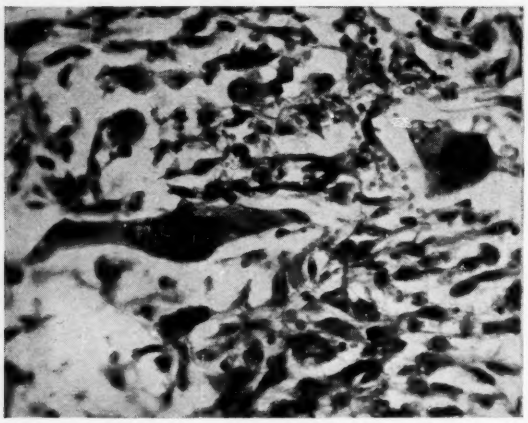

FIG. 16.—Microscopical appearance of the tumour depicted in *Fig.* 15, showing large myoblast cells.

case of a patient who underwent eight local interventions for a liposarcoma of the upper part of the thigh in the course of seven and a half years before death ended the scene, and they also record the history of a patient who actually underwent thirty-eight operations in five years!

TREATMENT

Radium Alone.—Of the 4 cases of my own *personal series* which were treated exclusively by radium, all ended fatally in a brief period of time, irrespective of the histological character of the tumour. In regard to the cases treated in Middlesex Hospital by radium alone, either in the form of surface or interstitial radium, a rapidly fatal result followed in every patient except one—a spindle-celled sarcoma of the popliteal space and upper part of the leg in a clergyman of 77 years, who survived to attain the age of 84. A doubtful recurrence in the left eye seven years after treatment was never verified histologically.

Deep X-ray Therapy and Surgery.—In respect of the 25 cases of the 'Middlesex' series treated by various combinations of radiotherapy (deep X rays) associated with surgery, it is not always easy to allocate the share which each agency has played in producing the end-result; nor must the histological characters of the tumour be forgotten. Nine cases of this series of 25 have survived five years or more; and in 4 of these there can be little doubt that deep X-ray therapy did incontestably contribute to the good result. But in many of the cases where deep X-ray therapy has been used, amputation has also been resorted to, and in fact no less than 6 of the 12 who attained four-year freedom from recurrence had undergone an amputation, usually a high one. Eight of this group of 25 cases were fibrosarcomata, and 12 or 13 were spindle-celled sarcomata.

Of a series of 16 cases treated by *surgery alone* in the Hospital series, 9 died, either at operation or in less than three years. Of the 4 still alive, one is alive at one year, another at one and a half years, another at over two years, and another at seven years.

My *private series*, where wide excision or amputation has constituted the method of treatment in 16 out of the 20 cases, shows rather better results. A patient with spindle-celled sarcoma of the infraspinatus is alive and well at thirty years; a patient with sarcoma of the supraspinatus is alive and well at thirteen years; a patient with a large ulcerating sarcoma of the adductor longus is alive and well ten years after amputation at the hip-joint; and many others out of the group have survived a not inconsiderable number of years.

Where the tumour is small and easily accessible, it will probably be excised, and if the histological picture prove to be sinister, some reliance may be placed on deep X-ray therapy.

Inspection of the figures emanating from surgeons and from radiotherapists indicates the tendency of these cases to recur at varying intervals of time. In most cases repeated excision leads to more rapid recurrence; but in the case of Professor Grey Turner[5]—a sarcoma of the vastus externus, which underwent local excision and recurred two years afterwards, and in which a second wide excision of the whole muscle was practised—the patient is still alive twenty years later.

It would be difficult to persuade a patient to subject himself to an amputation at the hip-joint, or through the thigh, for a small tumour which has occasioned no pain; and in these patients, the decision for amputation will rightly be postponed until recurrence takes place.

In cases where the tumour is voluminous, deeply seated, and inaccessible, and where thorough extirpation by these measures seems impossible or improbable, amputation is probably the best course. Many of the amputations at the hip-joint, or through the upper part of the thigh, have done well; and so have wide excisions in the neighbourhood of the shoulder-joint. But of cases of interinnomino-abdominal amputation for muscle sarcoma which are known to the writer, three died of pulmonary metastasis within a few months of the operation; the author, however, has one case in which the patient is alive and well over three years after that operation was performed for a sarcoma of the muscles of Scarpa's triangle (*Fig.* 17). The humane and artistic in every surgeon must revolt against mutilating operation and amputation as the necessary penalty to be paid for a prospective cure, and hopes naturally turn to radiotherapy as a less medieval and barbaric method of therapy; but unfortunately many of the tumours have only a low degree of radiosensitivity. Rhabdomyosarcoma is only very faintly radiosensitive, and although spindle-celled sarcoma has a moderate degree of radiosensitivity, that of fibrosarcoma is much lower (Radiumhemmet).

Moulonguet and Pollosson found many examples of radioresistance in their series; thus 26 tumours were radioresistant to 19 radiosensitive. These French authors affirm that certain forms of angioblastic sarcoma and lipoblastic sarcoma are the most radiosensitive of all.

With the object of ascertaining what results might be attained by an enthusiast in the treatment of these cases by radium alone or used in conjunction with surgery, I approached my friend, Mr. Stanford Cade, who most generously put his material at my disposal. His results afford ample justification for his enthusiasm and optimism. No less than 4 out of 5 cases dealt with by him up to 1939 are alive and well *ten years after*. Of 17 cases treated by him up to 1934, 8 are alive five years later, and there are 4 additional patients who are alive and well between

three and five years after treatment. In all, 12 out of his 24 cases of sarcomata of the muscles and connective-tissue planes of the limbs have survived more than three years. Radium alone has been used as the method of treatment in 10 of

FIG. 17.—Large spindle-cell sarcoma of adductor region and Scarpa's triangle of left thigh. Inter-innomino-abdominal operation. Patient alive and well more than three years afterwards. (*Gordon-Taylor.*)

Stanford Cade's cases, and 6 are still alive and well. Of these 10 cases, 6 were fibrosarcomata, a variety of sarcoma not commonly regarded as radiosensitive, but one has now survived ten years, and one eight years.

CONCLUSIONS

1. These tumours are infrequent, but for the most part highly malignant.

2. All tumours of the muscles or connective-tissue planes of the limbs should be regarded as suspect, and removed widely at the earliest moment. A histological diagnosis will thus be attained at a stage of the malignant tumour when surgery or radio-surgery has a brighter prospect of effecting a cure than usually obtains: on the other hand, if it be granted that on occasion malignant change in a benign tumour may occur, the removal of an innocent neoplasm is to be regarded as a prophylactic procedure of value, whereby a sinister transformation may have been anticipated.

3. A histological diagnosis is of paramount importance as a guide to the treatment of the sarcomata of the muscles and connective-tissue spaces of the extremity; information is thereby vouchsafed as to whether the methods of radiotherapy are worth a trial, the type of surgery required, etc. Whatever be the opinion entertained as to the dangers of a biopsy, this class of tumour is one in which the therapeutic value of exact histological data more than counterbalances the potential risks incurred by the patient in the acquisition of the information.

4. In regard to tumours of small or moderate dimensions, histological information and a cure may both be obtained anon by an adequate excision of the new growth, the scalpel being carried through healthy tissues far wide of the tumour. In the event of the malignancy of the neoplasm being attested by means of immediate microscopical investigations, radium may be left in the wound after ablation of the tumour. The experience of Stanford Cade furnishes indisputable evidence of the value of the employment of radium in this way. The utility of post-operative radiation seems still *sub judice*.

5. If the tumour is demonstrably confined to one muscle or even a group of muscles, the complete removal of that muscle or the muscle mass is indicated. If the neoplasm proves to be a rhabdomyosarcoma, amputation is probably best decided upon, for the results of less heroic measures are appalling; on the other hand, if the growth belong to one of the other varieties of sarcoma, surgical excision, radium, or radiosurgery may suffice.

6. If the tumour is of such a size that an attempt to remove it would obviously involve a mutilating operation or would engender grave doubts of its really effective extirpation, a biopsy must be performed by incision of the tumour. It is perhaps desirable that such a biopsy be preceded by radiation (Radiumhemmet).

Where the tumour proves to be of a radiosensitive variety, radiation may be tried; if of a radioresistant type, amputation at an appropriate site should be performed.

7. In amputation at the hip-joint and shoulder-joint it is important that the muscles be cut short. Forequarter amputations are devoid of operative mortality in competent hands, and the fatality of the hindquarter amputation is not too grievous when one recalls the prospects of a patient with a high sarcoma of the lower limb (*see Fig.* 17); results seem to justify the performance of the operation.

8. In the case of a recurrent tumour a wise discrimination must be employed in respect of the advisability of further conservativism or amputation. In a case of repeated recurrence amputation is to be counselled before it is too late.

9. The frequent history of repeated local operation and the end-results of conservatism suggest the propriety of more drastic surgery, especially amputation of the limb at an earlier date than has been customary heretofore.

10. Except in the case of obvious lipomata, the operation of enucleation should be barred, however enticing this procedure may be by reason of its simplicity. The capsule in cases of sarcomata of the limbs is a spurious structure, and microscopical evidence of the presence of islets of malignant cells outside the capsule has often been demonstrated.

11. The prognosis is best in those cases in which the initial stages of development have been latent or tardy; the cases in which the beginning is rapid continue to run the most hurricane course.

12. The curious fact that unoperated or untreated sarcomata die without evidence of metastases should not stay the hand of those called upon to treat. The life-history of such untreated cases is usually only a few years, whereas cures of twenty years and more have been attained by surgery.

13. This paper may afford some guide to the geographical habitat of the more characteristic specimens illustrating sarcomata of the muscles of the limbs and of the connective-tissue planes of the extremities in the museums of Great Britain.

It affords me the greatest pleasure to express my indebtedness to the curators of the various pathological museums throughout the country who have shown me their treasures and who have kindly permitted me to have them reproduced. Many artists have shared the labours of illustrating the specimens which form the basis of this communication; to all I tender my most grateful thanks. The beautiful microscopical preparation at the beginning of this paper is the work of Dr. E. K. Dawson, of the Laboratories of the Royal College of Physicians, Edinburgh, who has been unstinting of effort to enable me to gather the fruits of journeys throughout the length and breadth of Great Britain in search of sarcomata of the muscles of the limbs. Several of my surgical friends have been most generous in supplying me with clinical details relating to specimens which have now reached and occupy pathological shelves; in particular I would express my sincerest obligations for their trouble to Mr. Stanford Cade, Professor Davie, Mr. Harry Platt, Mr. R. Davies-Colley, Professor S. L. Baker, Professor R. W. Alexander, of Dundee, Professor Grey Turner, Professor Illingworth, now of Glasgow, and Dr. Proger of the Royal College of Surgeons of England. Finally, my own colleagues at Middlesex Hospital have generously allowed me to make use of their cases, which constitute what I have termed here the 'Middlesex' series; the wealth of surgical material of my friend Mr. Sampson Handley has indeed been invaluable, and provided me with some of the illustrations which adorn this paper.

BIBLIOGRAPHY

[1] MOULONGUET, PIERRE, and POLLOSSON, EUGÈNE, *Rapport Assoc. franç. de Chir., XLVII Congrès franç. de Chir.*, 1938.
[2] JÖNSSON, GUNNAR, *Acta radiol.*, supp. XXXVI, 1938.
[3] CAPPELL, D. F., and MONTGOMERY, G. L., *Jour. Pathol. and Bacteriol.*, 1937, **44**, 517.
[4] THIEM and BRAMANN, quoted by MOULONGUET and POLLOSSON.
[5] RAZEMON, P., VANDENDORP, F., and DRIESSENS, J., *Ann. d'Anat. pathol.*, 1938, **15**, 971.
[6] TURNER, G. GREY, Murphy Oration, 1930, and personal communication.

SKELETAL MUSCLE TISSUE TUMOUR*

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THE skeletal muscles form a very large element in the composition of the body, yet tumour formation from this particular type of tissue is surprisingly uncommon. A number of cases have, however, been reported from time to time by different workers. Apart from the earlier reported cases of rhabdomyoma, Ewing (1931) and Abrikossoff (1926, 1931), who described the myoblastic forms of these tumours, have thrown considerable light on their histology. Cappell and Montgomery (1937) extended the knowledge of these tumours still further, and clearly differentiated between the two forms of striated muscle tumours—namely, rhabdomyomas, i.e., tumours showing elements with definite striations, and myoblastomas, or tumours which show no striation. These workers also observed the difficulties of correlation of the cellular structure and the clinical behaviour of myoblastomas, thus introducing a further interest in these types of neoplasia. Considering the rarity and the incomplete pathology of these tumours, it has been thought worth while to record the following 14 cases of striated muscle tissue tumours which we have been able to collect.

CASE REPORTS

Procedure Adopted.—All the materials were stained with Van Gieson and Mallory's aniline blue stains, besides the routine iron hæmatoxylin and eosin method. In those cases where there was any possibility of detection of muscular striation, Heidenhain's iron hæmatoxylin stain was adopted. By the application of these methods the muscular element was differentiated from other tissue components in every case.

Case 1.—

HISTORY.—N. D., female, aged 46, married, was admitted into the Medical College Hospital, Calcutta, on July 29, 1935, with a hard swelling on the medial side of the junction of the upper third and lower two-thirds of the right thigh. Three years before a small tumour mass appeared at the site and the growth was removed by operation in a district hospital, where the histological examination showed the picture of a spindle-cell sarcoma (slide not available). The patient had nine deep X-ray exposures after the operation. The recurrence appeared eight months afterwards, and it gradually continued to grow until it reached its present state, for which she came to the hospital. No relevant family history; no history of trauma.

ON EXAMINATION.—A circular swelling 4 in. in diameter on the anterior aspect of the junction of the upper third and lower two-thirds of the thigh. The tumour felt hard, but it was neither tender nor hot. The surrounding area was painful, and there was loss of sensation over the anterior and lateral aspect of the thigh below. Skin was adherent to the growth, the margins of which were well defined.

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The tumour was removed by operation, during which it was found to be situated superficial to the fascia lata.

HISTOLOGICAL EXAMINATION.—The tumour showed mainly the structure of a spindle-cell sarcoma, but on closer observation embryonic muscle cells were evident. These consisted of large intensely acidophilic cytoplasm containing a number of nuclei arranged irregularly with very fine transverse striations. Long gigantic spindle cells with longitudinal striations at the tail end of the cells were seen. A number of spider cells was also found. From the histological appearances it was clear that this was a case of rhabdomyoma sarcomatodes, as described by Cappell and Montgomery (1937).

POST-OPERATIVE PROGRESS.—After operation the patient made an uninterrupted recovery and was discharged and taken to her country home on Aug. 24, 1935. A vague pain persisted at the site of the tumour.

Three months later a swelling appeared in situ and grew to the size of a football. A month later a small nodule appeared on the lower abdomen, and this was followed by the appearance of a mass, the size of an orange, on the left side of the sternum. Two months later another tumour mass appeared on the right buttock. The patient went downhill, and died seven months after her discharge from the hospital. During the terminal stage the patient could not swallow any food and suppression of urine occurred. No autopsy was available.

Case 2.—

HISTORY.—A. A., male, aged 13, came to the hospital on Sept. 13, 1935, for a tumour on the left axilla. About a year back the patient noticed a swelling in the left axilla which slowly increased.

ON EXAMINATION.—A hard tumour about 3 in. × 2½ in. in size was found. It was adherent to the skin. No history relevant to the appearance of the growth was found.

The tumour was removed by operation.

HISTOLOGICAL EXAMINATION OF THE SPECIMEN.—Below the cutaneous layer there were columns of muscle cells which were of adult type. On higher magnification, distinct muscular bundles were apparent, some of which were seen to be cut transversely, while others showing longitudinal arrangement with faint transverse striations were also found. No embryonic cells were seen, but the entire tumour was composed of the above type of tissue. The case was a striated muscle tissue tumour of benign variety, which Cappell has described as a simple rhabdomyoma.

POST-OPERATIVE PROGRESS.—The patient was traced and examined on June 5, 1939, and was found to be a healthy grown-up boy. There was no recurrence on the site of the tumour, which showed only a scar.

Case 3.—

HISTORY.—A. M., male, married, aged 38, a cultivator by occupation, was admitted into the hospital on May 6, 1936, for an ulceration on the dorsum of the right hand and lower part of the forearm of 5 years' duration. Six years ago the patient developed a small swelling between the fourth and fifth metacarpal bones of the right hand on its dorsal aspect. The swelling broke down as a result of scratching and an ulcer developed. This ulcer never showed any tendency to healing, but extended in spite of treatment. One year ago the affected area was removed by operation, but a bigger ulcerated area developed at the site, for which he went to the hospital for aid.

ON EXAMINATION.—A sloughing ulcer 5 in. × 4½ in. in size was found on the dorsum and palm of the right hand on the medial side. The ulcer was bone-deep. The patient could not move the wrist joint. No glandular enlargement. There was a history of syphilis, but blood-Wassermann reaction was negative. X-ray examination showed some periosteal reaction of the wrist-joint. A major portion of the fifth metacarpal bone was eroded and dactylitis of the fourth metacarpal bone and arthritic changes in the fourth metacarpo-phalangeal joint were found.

A malignant process was suspected and the right arm was amputated at the lower third. A course of deep X-ray therapy was given, and the patient made an uneventful recovery. He was discharged from the hospital on July 7, 1936.

HISTOLOGICAL EXAMINATION OF THE TUMOUR.—The tissue showed a uniform structural pattern, which was composed of large spindle-shaped cells with distinct vesicular nuclei and

deep acidophilic cytoplasm. Besides these there were irregular protoplasmic masses with a number of vesicular nuclei (*Fig.* 18). These tumour cells were devoid of striation, and even with Heidenhain's iron hæmatoxylin stain no trace of it could be seen. The picture was that of a typical myoblastoma. In addition, at certain areas there were signs of acute and subacute types of inflammation.

POST-OPERATIVE HISTORY.—He died in the month of June, 1938, i.e., more than two years after operation, from an attack of pulmonary tuberculosis. Inquiry from the patient's relations revealed that he had no recurrence of the tumour up to his death.

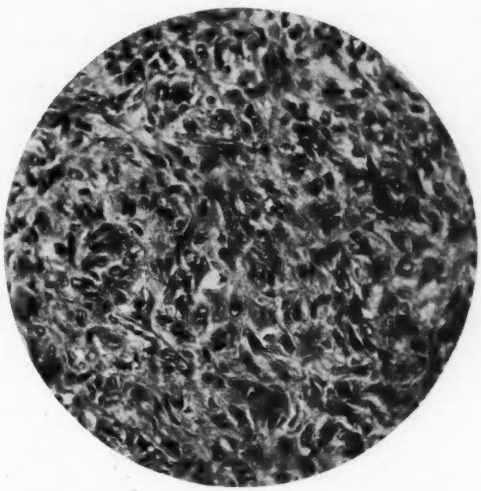

FIG. 18.—*Case* 3. Photomicrograph showing the nature of the cells in detail; the syncytial protoplasmic masses are prominent and the vesicular nature of the nuclei is apparent.

Case 4.—

HISTORY.—M. S., unmarried college girl, aged 20, was admitted into the hospital on Nov. 2, 1931, with the following history: In the month of January, 1931, she had a fall from a height and was hurt in the left axillary and shoulder region. A certain amount of pain persisted for about a fortnight, otherwise she had never any trouble. About the first week of April next the pain recurred, and in the following month she noticed a lump on the posterior aspect of the left axilla which grew to the size of a lemon. In spite of palliative treatment the mass continued to grow and finally became as large as a cricket ball. It was round in shape, felt hard, and was uneven.

ON EXAMINATION.—At this stage she was examined by a surgeon, who found that the tumour occupied the space between the teres muscles and the latissimus dorsi, but not actually filling up the axillary space. There was not much pain or tenderness. A constant tingling benumbed feeling was felt in the left arm. She was sent to the hospital with a diagnosis of a suspected malignant tumour.

X-ray examination did not reveal any unusual finding.

AT OPERATION.—The tumour was operated on, and it was found that it was somewhat adherent to the lower angle of the scapula. After operation twelve radium needles were embedded all round the space occupied by the teres muscles, latissimus dorsi, and the serratus anterior, which formed the floor of the tumour.

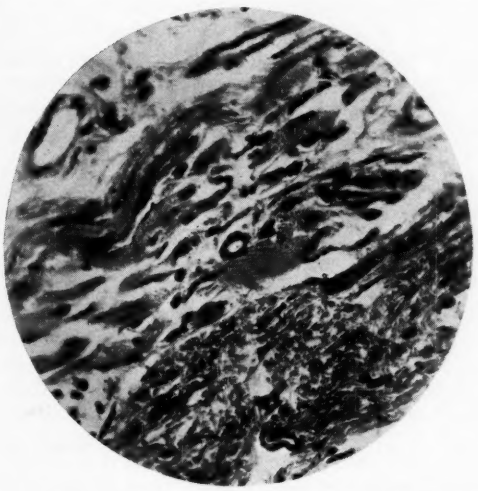

FIG. 19.—*Case* 4. High-power photomicrograph showing distinct cross-striation in some of the muscular elements in the tumour. (Heidenhain's iron hæmotoxylin stain.)

HISTOLOGICAL EXAMINATION.—In the midst of connective tissue, the muscular element in the tumour is evident. On higher magnification distinct cross-striation could be seen (*Fig.* 19). Some portions were mainly composed of muscle tissue, which showed as small elongated rudimentary fibres in the midst of which isolated adult muscle tissue with transverse striations was present. In some areas connective tissue was the main element, within which occasionally islands of single embryonic muscle cells could be detected. On microscopical examination, this case proved to be a malignant muscle-tissue tumour, i.e., rhabdomyoma sarcomatodes.

POST-OPERATIVE PROGRESS.—The patient was discharged from the hospital a month after the operation with no apparent complaints. She stayed in her country district, when, six months later, a small swelling appeared at the site of the tumour, which was again operated upon at her district hospital (material not available) and apparently cured. She was married in the meantime.

In 1933 she felt a burning sensation at the site of the tumour; this disappeared after a few months.

In 1935 the patient felt pain at the lower part of her left arm and a mass appeared near the elbow. A course of deep X-ray therapy was applied to the site.

In early 1936 she was delivered of a child. In June, 1936, another swelling appeared at the site of the original tumour which after a month became ulcerated and a small piece of bone came out.

In 1937 the swelling of the elbow-joint began to enlarge, accompanied by pain, for which deep X-ray therapy was again given.

When examined in 1939 she appeared in good general health, but an irregular swelling at the elbow-joint could be seen. The arm could not be raised, but hung loose by her side.

FIG. 20.—*Case* 5. Photomicrograph showing the commencing faint transverse striation in the cytoplasm of the cell. (Heidenhain's iron hæmotoxylin stain.)

Case 5.—

HISTORY.—A. S. K., male, aged 39, supervisor in a bank, was admitted into the hospital on Oct. 29, 1938, for a painful swelling on the distal and medial part of the right thigh of three months' duration.

About a month prior to his admission, the patient felt a pain in the right knee-joint and noticed a small swelling on the above-mentioned part of the right thigh. Gradually the swelling increased in size, and the pain became more severe, for which he came to the hospital. There was no history of trauma. History of a soft sore and a bubo ten years back. Blood-Wassermann was negative.

ON EXAMINATION.—A swelling, 5½ in. × 4½ in. in size, on the distal and medial part of the right thigh, oblong in shape, the upper end being narrower than the lower, was found. The tumour felt firm, without any fluctuation, and on deep pressure tenderness was elicited. The skin was hot, but free. The tumour was movable from side to side, but not from above downwards. No enlargement of the regional lymph-glands was found. X-ray examination showed no involvement of bone.

AT OPERATION.—The tumour was removed by operation, when it was found to be growing from among the muscles and was cartilaginous in consistency; 26 mg. of radium was inserted. The patient was discharged on Nov. 18, 1938.

HISTOLOGICAL EXAMINATION.—The growth was composed of muscle tissue, which showed as large cells of various sizes with multiple vesicular nuclei and deep acidophilic cytoplasm. Besides these, many narrow elongated embryonic muscle cells of different sizes could be seen. Some of the bigger cells on high magnification showed distinct transverse striation in their acidophilic cytoplasm (*Fig.* 20).

AFTER-HISTORY.—The patient was traced and examined on July 28, 1939, and was found to be able to carry on his work as usual in apparent good health. The site of the tumour did not reveal any recurrence, nor was there any evidence of distant metastasis.

Case 6.—

HISTORY.—V. S., male, aged 36, a fitter in a workshop, about the month of March, 1934, developed a small warty growth on the inner side of the left breast just outside the areola. It continued to grow, and in six months' time reached the size of 2½ in. × 2 in. and became ulcerated.

ON EXAMINATION.—Gynæcomastia of both the breasts. There was no glandular enlargement. X-ray examination showed only a shadow of hilar glands.

The tumour was removed by operation and on exposing the muscles it was seen that it did not arise from the muscles.

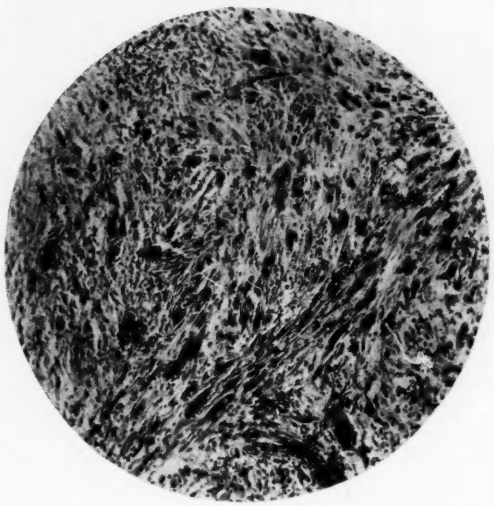

FIG. 21.—*Case* 6. Low-power photomicrograph showing the gigantic spindle-shaped cells and protoplasmic masses with vesiculated nuclei.

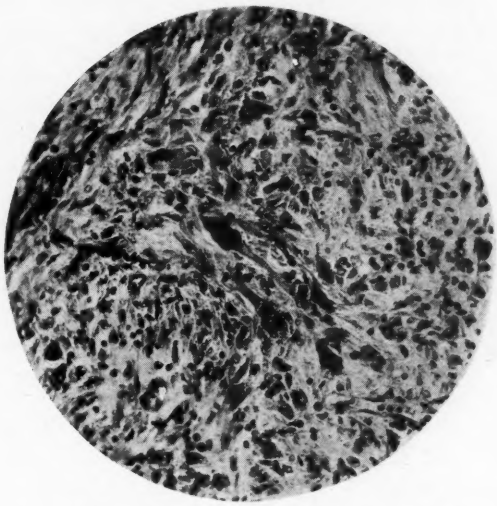

FIG. 22.—*Case* 6. Photomicrograph showing the structural elements in another area of the tumour. In the centre two large spindle cells can be seen with distinct transverse striations at their tail ends. (Heidenhain's iron hæmotoxylin stain.)

HISTOLOGICAL EXAMINATION.—The picture was composed mainly of numerous large spindle cells with multiple vesicular nuclei and many giant cells of syncytial type (*Fig.* 21). Some of the gigantic spindle cells showed transverse striations at their tail end (*Fig.* 22).

AFTER-HISTORY.—On April 29, 1939, the patient was again examined, and was found to be carrying on his profession as usual in apparent good health. The area of the tumour showed a big prominent scar measuring $\frac{4}{5}$ in., with a number of ridges arranged in a star-shaped manner. There was no gynæcomastia of the operated side, but the right side still showed it. There was no sign of any recurrence.

FIG. 23.—*Case* 7. Photomicrograph showing the structures in detail. The vesicular type of nucleus and the absence of striation are well shown.

Case 7.—

HISTORY.—S. M., female, aged 70, European Christian missionary, was admitted into hospital for a tumour on the right cheek on Nov. 17, 1938. A small pimple was noted at the site about 14 weeks prior to her admission. The pimple burst, but no pus discharge was noted, although a slow hæmorrhage persisted for a few days. Treatment with iodine and silver nitrate proved of no value. The tumour slowly grew to the present size.

ON EXAMINATION.—A pedunculated growth, $\frac{1}{2}$ in. × $\frac{3}{4}$ in. in size, was found on the right cheek about an inch from the angle of the mouth. There were small exuberances in the tumour, which bled easily. No glandular enlargement was noticed.

AT OPERATION.—The growth was removed by surgical diathermy, including ¼ in. of skin on either side down to the muscular fibres of the buccinator, and a collar stud of 2·65 mg. of radium was applied for 48 hours.

HISTOLOGICAL EXAMINATION.—The tumour showed closely packed large spindle cells with marked acidophilic cytoplasm and vesicular nuclei, with very little intracellular substance. On higher magnification typical myoblastic cells were apparent (*Fig.* 23). The whole of the tumour was of uniform cellular pattern as described above, and no striations whatsoever could be detected. On histological grounds this was a case of pure myoblastoma.

AFTER-HISTORY.—The patient was examined on July, 1939, and was found to be quite healthy except for a certain amount of anæmia. At the site of the tumour only a small scar was noticed.

Case 8.—

K. S., female, aged 8 years, sought surgical aid in the early part of September, 1936, for a small nodular swelling measuring about ¾ in. in diameter on the medial aspect of the labia majora. On examination it was found to be a rather hard mass which could be felt about ¾ in. below the surface. The mass was completely excised.

She was examined last in June, 1939. No recurrence in situ, nor any evidence of metastasis was found.

HISTOLOGICAL EXAMINATION OF THE TUMOUR.—It was found to consist of muscular tissue. Columns of muscular fibres, which were of adult type, were interspersed with fibrous tissue. On higher magnification the muscular nature of the growth was quite evident and the fibres were arranged in columns. There were no anaplastic cells. Evidently the case was a non-malignant rhabdomyoma.

Case 9.—

HISTORY.—A. C. K., male, aged 50, cultivator by occupation, was admitted into the hospital on March 30, 1937, for a swelling on the upper part of the right arm. About two years previously a swelling nearly the size of a pea appeared on the outer aspect of the upper part of the right arm. There was no history of any trauma. The patient's general health showed gradual deterioration without any apparent cause.

ON EXAMINATION.—An irregular swelling situated in the middle of the right upper arm on its outer aspect, measuring about 5 in. along the length of the humerus and 7 in. at its widest part. Over the swelling there were three nodules, and near the middle of the swelling there was an ulcer 1 in. in diameter covered with a brownish scab, being the result of indigenous application. The mass was firm and elastic, but at places it felt hard. There was no tenderness and the growth was not fixed to the skin except at the area of the ulcer. Axillary glands could not be felt.

X-ray examination showed that the bone was mostly free, but about 1½ in. below the head of the humerus there was a dense homogeneous shadow corresponding to the swelling.

Histological examination from the biopsy material showed the following: There were long cylindrical muscle-fibres at places, but the predominant picture was composed of irregular mono- and multinucleated syncytial masses with a vesicular type of nuclei arranged at the periphery of the masses. In some of these cells faint transverse striations, i.e., embryonic muscle cells, could be seen with Heidenhain's iron hæmatoxylin stain. Under higher magnification the muscular nature of the tumour was well seen. There were transverse and cross striations quite prominent in many areas. This tumour was mainly composed of a sarcomatous type of muscular elements, and myoblastic cells were not seen.

PROGRESS.—While in the hospital the patient used to get occasional bouts of fever. On April 21, 1937, he suddenly developed tetanic symptoms and died the next day. No autopsy was made.

Case 10.—

HISTORY.—I. M. D., female, aged 48 years, was admitted into the hospital on July 20, 1933, for a growth on the right cheek. Three years ago a small nodular swelling appeared on the right cheek and it continued to grow to the size of a betel nut. This growth was excised, and a few months later a tumour appeared at the original site, for which she came to the hospital for further treatment.

ON EXAMINATION.—A globular mass, 2½ in. × 1½ in. in size, was found over the right malar region, a little below the right infra-orbital area. Skin over the growth was darker

than the general body pigmentation, and was shiny in appearance. The growth was circumscribed and felt hard. The skin over the tumour was adherent and tender. A clinical diagnosis of neurofibroma was made.

PROGRESS.—The tumour was excised, and the patient was discharged as cured a fortnight after the operation. She could not, however, be traced, and consequently no after-history was available.

HISTOLOGICAL EXAMINATION.—The excised tumour, contrary to the clinical diagnosis, revealed the presence of long spindle cells with vesicular nuclei and irregular protoplasmic areas. It showed very scanty intercellular substance. There was no evidence of any striation. The picture was that of a myoblastoma.

Case 11.—

HISTORY.—N. S., male, aged 48 years, was admitted into the hospital in March, 1939, with a provisional diagnosis of osteogenic sarcoma of the lower end of the right femur. While a student, the patient had a painful swelling of the right knee-joint as a result of a trauma, which gradually subsided. About twelve years before admission he had a fall and

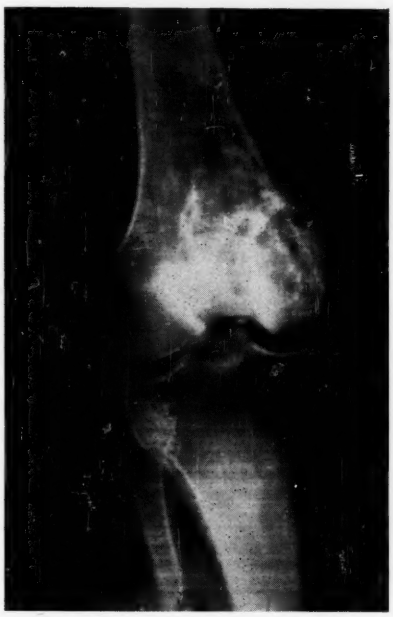

FIG. 24.—*Case* 11. Radiograph showing definite bony involvement of the lower end of the femur.

FIG. 25.—*Case* 11. Radiograph showing the neoplastic process involving the lower end and some portion of the shaft of the femur.

received an injury on the same knee, a painful swelling developing, for which he had to be in bed for some days. Since that accident he had painful swelling on the same knee off and on, and this used to subside on rest and local treatment. At the beginning of 1938 the condition grew worse, and in February, 1938, when a radiograph was taken, the radiological report showed osteophytic formation at the margins of the articular surfaces of the lower end of the right femur and upper ends of the right tibia and fibula, as well as at the margin of the patella. Gradually the condition grew worse, and another radiograph taken in August, 1938, showed a definite bony involvement of the lower end of the femur (*Fig.* 24). At this time the swelling grew considerably and the patient had to take to bed. In February, 1939, another X-ray picture was taken, and it showed extensive infiltration of most of the lower end and some portion of the shaft of the femur (*Fig.* 25).

A diagnosis of osteogenic sarcoma was made and the leg was amputated.

THE SPECIMEN.—A sagittal section of the knee-joint showed the following: A tumour mass of 7 in. × 5 in. was seen completely encircling the lower end of the femur, which

together with the lower third of the shaft of the bone showed extensive changes (*Fig.* 26). The bony surface was found eroded at certain parts. The extra-osseous portion of the tumour was found to arise and was connected with the muscles of the leg and thigh. It had the consistency of cartilage and was found to be in direct continuity with the muscles. The colour varied: the part nearest to the muscles was flesh pink, whereas the deeper portion of the mass was almost whitish, and this change of colour from buff to white was gradual. The osseous portion of the tumour was found to consist of dark red and yellow areas within the bone, which while cutting with a knife presented a definite hard cartilage-like consistency. The histological picture of the extra-osseous part of the tumour was found to be composed of two different types of cellular pattern, one of which showed mainly irregular intensely acidophilic protoplasmic masses with vacuolated nuclei, and long cylindrical cells. The other part was composed of connective tissue, within which immature muscle cells showing distinct longitudinal and cross striations were conspicuous. The osseous portion of the tumour showed long gigantic cylindrical cells and also irregular syncytial masses. In the number of blocks studied no striated muscle cells could be seen in the osseous part of the tumour.

This tumour was composed both of striated and non-striated elements of muscle tissue. From the extensive growth and the infiltration of the bone, malignancy was evident and the microscopical picture also confirmed this.

AFTER-HISTORY.—The patient was discharged from hospital a month after the amputation. He was without any complaints for about a month after his discharge, then he started to feel a pain over his lumbar region, which gradually became excruciating and he had to be kept continuously on morphia. A radiograph was taken and the fourth lumbar vertebra was found to have an infiltration which resulted in a fracture of that bone. This was the condition of the patient at the time of reporting.

FIG. 26.—*Case* 11. Photograph of the sagittal section of the knee, showing both the extra-osseous and osseous portions of the tumour. The fleshy growth completely surrounded the bone, the middle portion of which has been partially removed to show the lower end of the femur.

Case 12.—

HISTORY.—K. C. S., male, aged 45 years, was admitted into the hospital on May 2, 1934, for an ulcerated growth on the tongue and difficulty in deglutition. Nine years before the patient noticed a small growth on the left margin of the tongue which continued to grow bigger until it reached the size of a pea. It was removed by operation. Three years afterwards the growth re-appeared on the exact spot and was again excised; radium treatment was applied. A year later it recurred and grew very quickly and small ulcers developed, for which he came to the hospital.

ON EXAMINATION.—A tumour mass 2½ in. × 2 in. was found on the left half of the dorsum of the tongue. The growth was pinkish in colour and was divided by a linear furrow into a larger medial and smaller lateral half. A number of small pitted ulcers with clear margins were seen on the lateral half of the tumour. Neck lymph-glands were not palpable.

HISTOLOGICAL EXAMINATION OF THE TUMOUR.—On hemisection of the tongue the tumour was found to arise from the muscles of the tongue and was well defined and circumscribed, with a homogeneous consistency. The general picture resembled the structure of a spindled-celled sarcoma, but on closer observation large syncytial masses with vesicular nuclei could be seen which indicated the muscular origin of the tumour. In other areas, in the midst of long spindle-shaped cells, a definite muscular element with transverse

striations was detected. Microscopically this case was that of a sarcomatous type of rhabdomyoma.

AFTER-HISTORY.—A month after operation he was discharged from the hospital apparently cured. Four months later the growth recurred at the site. The patient refused to take hospital aid and tried some other methods of cure. On March 3, 1935, he died from the effects of a massive growth of the tongue—namely, cachexia and obstruction.

Case 13.—

HISTORY.—K. S., male, aged 11, was admitted into the hospital on May 1, 1939, for a swelling of the lower part of the right lower limb for the last three years and pain in that region for the last six months. The regional swelling began three years before at a small area, but since the last six months it had increased very rapidly and was accompanied by pain.

ON EXAMINATION.—A huge uniform soft swelling, 5 in. × 3 in., was seen on the lower part of the lateral side of the right lower limb. The neighbouring joints, the ankle and knee, were free. The skin was very tense, but was not adherent to the growth. Radiological examination showed periosteal thickening of the tibia and fibula and osteoporosis of the tibia. A gummatous lesion or Ewing's tumour was suggested. Blood-Wassermann reaction was negative.

The leg was amputated.

THE SPECIMEN.—The sagittal section of the excised leg showed an extensive tumour mass directly connected with the calf muscles. It was whitish in colour. Both the tibia and fibula showed extensive infiltration, which consisted of brownish and hæmorrhagic areas. The bony shell was found to be

FIG. 27.—*Case* 13. Photograph of the sagittal section of the amputated leg, showing the hæmorrhagic areas in the fleshy part and extensive involvement of the bone which is in direct continuity with the main portion of the tumour.

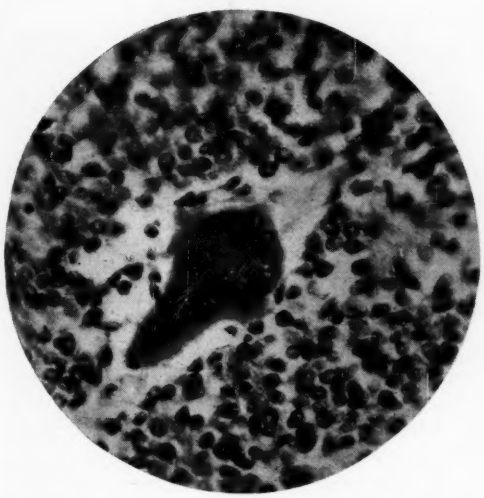

FIG. 28.—*Case* 13. Photomicrograph of the extra-osseous part of the tumour, showing the round cells and a single protoplasmic syncytial mass with multiple nuclei arranged at the periphery. (Van Gieson stain.)

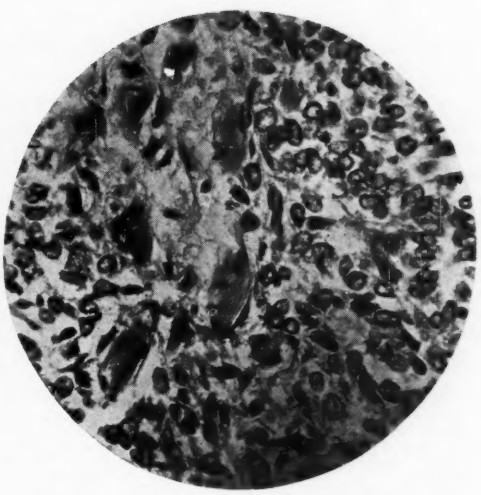

FIG. 29.—*Case* 13. Photomicrograph showing a portion of the fleshy part of the tumour, which consisted mostly of round cells. Within these, muscle cells of different sizes with longitudinal striations are seen. Note the vacuolated nature of the cells.

thinned out, and at places the fleshy tumour was in continuity with the bony portion (*Fig.* 27). There were also a number of actual hæmorrhagic areas in the muscular part of the tumour. The microscopical appearance of the extra-osseous part showed mainly round cells and connective tissue, within which embryonic muscle cells were conspicuous. The round cells on higher magnification showed scanty cytoplasm and vacuolation (*Figs.* 28, 29). The osseous portion of the tumour showed round cells and immature muscle-fibres with longitudinal and cross striations. A portion of the bone was also seen in this field. From the microscopical appearance the sarcomatous nature of the growth is unmistakable.

The amputated wound being healed up, the patient was discharged on June 7, 1939. Although the after-history is not available at the present moment, the malignant nature of the tumour is well established.

Case 14.—

HISTORY.—L. T., female, aged 16, sought hospital aid on June 25, 1939, for a growth in the nasopharyngeal region producing obstruction of the air-passages.

FIG. 30.—*Case* 14. High-power photomicrograph showing the syncytial protoplasmic masses with multiple nuclei.

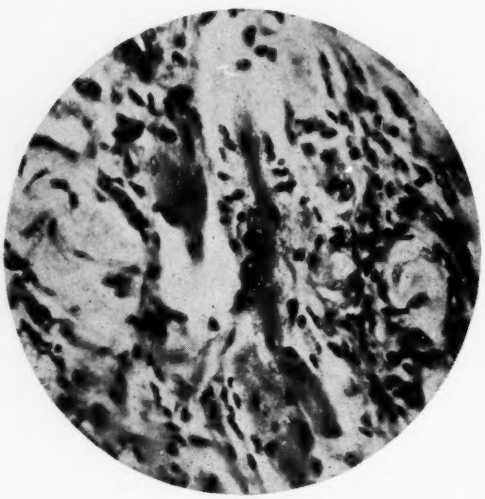

FIG. 31.—*Case* 14. High-power photomicrograph showing an immature muscle-fibre with cross-striations lying at the centre of the field. On the left side a syncytial mass with multiple nuclei is also to be seen. (Heidenhain's iron hæmotoxylin stain.)

ON EXAMINATION.—A polypoid growth, the size of a plum, arising from the posterior wall of the nasopharynx and occupying the entire area was seen to protrude downwards and forwards. The mass was covered by the mucous membrane. The patient was breathing through the mouth. There was no enlargement of the regional glands. A clinical diagnosis of fibrosarcoma was made.

The growth was removed by operation. The tumour was not very vascular and felt fibrous to the touch.

HISTOLOGICAL EXAMINATION.—There were columns of round cells interspersed by connective-tissue strands within which there were long spindle cells. In some portions syncytial protoplasmic masses, in different shapes and sizes, with multiple nuclei, were prominent. These nuclei in some cells occupied the whole of the protoplasmic masses, in others the central part, and in some were found at one end of the cell (*Fig.* 30). The presence of long immature muscle-fibres with definite cross-striations was another feature of the tumour (*Fig.* 31). Thus the muscular nature of the tumour was clear and its sarcomatous nature evident.

The operation wound having healed, the patient was discharged, and the subsequent progress of this case is under observation. It is expected to run a malignant course.

DISCUSSION AND COMMENTS

Histological.—Adult skeletal muscle cells are developed from their precursors, the myoblasts. In the course of development they pass through the stages of round cells, elongated spindle-shaped cells, to the stage of striated cells. Hence in the course of aberrative tumour formation these types of cellular structures may be encountered. A tumour of muscle-tissue origin might present all these stages or may be composed of any one of them. After the works of Abrikossoff and of Cappell and Montgomery, our ideas about voluntary muscle tumours have been much clarified, and it is evident that fragments of tissue showing elements with no striations might not rule out the possibility of muscle tissue altogether. It is, however, difficult to diagnose a tumour of voluntary muscle tissue from a cellular picture of highly anaplastic stages alone, such as round cells or spindle cells; but wherever there is any suspicion, a sufficient number of blocks from different areas should be carefully studied for the possibility of discovering a striated element, which should finally clinch the diagnosis of a rhabdomyoma. In our series a number of cases were previously reported as mixed-cell sarcoma and fibrosarcoma, but study of further material revealed the presence of undifferentiated striated element in the tumour mass, depicting the true nature of these tumours. In our series of 14 cases the following are the cellular types that we have found :—

Group A: Tumours composed of cells altogether devoid of any striations, i.e., pure myoblastomas (*Cases* 3, 7, 10).

Group B: Tumours composed of cells mainly as above, but with commencing striations in a few cells. These we like to consider as transitional forms of tumours between myoblastomas and rhabdomyomas (*Cases* 5, 6).

Group C: Tumours composed of round cells, spindle cells, large protoplasmic syncytial masses, and undifferentiated embryonic striated muscle cells, i.e., cases which Cappell and Montgomery described as rhabdomyoma sarcomatodes (*Cases* 1, 4, 9, 11, 12, 13, 14).

Group D: Tumours composed of fully differentiated adult muscle cells, viz., rhabdomyoma simplex (*Cases* 2, 8).

Clinical.—

1. *Age.*—All the cases were of adult age excepting *Case* 8, aged 8, *Case* 13, aged 11, and *Case* 2, aged 13.

2. *Sex.*—There were 6 cases in females and 8 cases in males.

3. *Trauma.*—Only 2 cases had a definite history of trauma.

4. *Site.*—The tumours occurred in the following situations: Face, 2; Thigh, 2; Arm, 2; Axilla, 2; Knee, 1; Breast, 1; Labia majora, 1; Tongue, 1; Nasopharynx, 1; and Leg, 1.

5. *Malignancy.*—There is general agreement that pure myoblastoma is not malignant in nature. Malignancy of any growth is determined by its local tissue invasiveness and power to produce metastasis. In *Group A*, *Cases* 3 and 10 are histologically pure myoblastomas, but recurrence after excision in both these cases and the extensive local tissue destruction in *Case* 3 created suspicion about their entirely benign nature. In *Group B*, *Cases* 5 and 6 are described as transitional forms on histological grounds; the benign nature of *Case* 6 is apparent. *Case* 5 has been followed up for only ten months after the operation and the period is too early to determine its clinical nature. In *Group C* the clinical behaviour of

Cases 9 and 14 remains uncertain, whereas *Cases* 1, 4, 11, 12, and 13 are definitely malignant. *Cases* 11 and 13 showed extension to the bone. *Case* 11 showed a number of interesting features. On radiological grounds (*Fig.* 25) a diagnosis of osteogenic sarcoma was justifiable, and until we examined the extra-osseous portion of the tumour we had no other idea. The extra-osseous tumour was shown to originate from voluntary muscle. In the bony part we got only long spindle cells and irregular protoplasmic masses, and we failed to get any striated element within it. If the bony part of the tumour is taken to be of other than muscular origin, then we are faced with the possibility of there being two different types of growth at the same site (*Fig.* 26) which is rather unlikely. On the other hand, the type of picture seen in the bony growth is quite compatible with the probability of the muscular origin of this part of the growth. It seems reasonable to infer that the osteophytic growths acted as a prolonged irritant, which might have resulted in a muscular neoplasm with its spread within the bone, and in our opinion this hypothesis seems more tenable.

SUMMARY AND CONCLUSIONS

1. Fourteen cases of tumour believed to originate from striated muscle are described—3 cases of pure myoblastoma, 2 cases of transitional types, 7 cases of rhabdomyoma sarcomatodes, and 2 cases of simple rhabdomyoma.

2. The histology and the clinical manifestations of these tumours are discussed.

In conclusion, our thanks are due to the Superintendent, Medical College Hospitals, Calcutta, for their records; to the Superintendent, Presidency General Hospital, Calcutta, for the records of *Cases* 7 and 14; and to Dr. P. Chatterjee, Honorary Surgeon, Medical College Hospitals, for the radiological pictures of *Case* 11. Our thanks are also due to the staff of the Pathology Department, Calcutta Medical College, and especially to Dr. B. N. Mukherjee, Clinical Pathologist to the Surgical Services, for his hard work and loyal co-operation in collecting the relevant data.

REFERENCES

[1] ABRIKOSSOFF, A. I., *Virchows Arch.*, 1926, **260**, 215.
[2] ABRIKOSSOFF, A. I., *Ibid.*, 1931, **280**, 723.
[3] CAPPELL, D. F., and MONTGOMERY, G. L., *Jour. Pathol. and Bacteriol.*, 1937, **44**, 517.
[4] EWING, *Neoplastic Diseases*, 3rd ed., 1931, 234. Philadelphia: W. B. Saunders Co.

THE TREATMENT OF MIXED TUMOURS OF THE PAROTID GLAND

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THE study of the histology of mixed tumours and speculation on their origin have proved such fascinating subjects that until comparatively recent times the question of treatment has tended to be overshadowed. But within the last decade or so it has been realized that all was not well in the treatment of these tumours, and there has been more active consideration of why this should be so, and of what should be done to remedy the situation. The time now seems ripe for a review of the position. The present article is based partly on the experience of others as revealed in the more recent literature, and partly on cases from the surgical and radiological records of the Middlesex Hospital, some of which have been under my own care and some under the care of my colleagues, to whom I am indebted for permission to refer to the cases here. As a first step, an attempt will be made to assess the natural course of the disease; that is to say, what may be expected to happen if nothing at all is done. This forms an essential background to a consideration of the results and risks of active treatment, and the advisability of running these risks in any particular case. And then will follow a consideration of the different types of treatment that have been advocated, and their results as far as can at present be ascertained.

THE NATURAL COURSE OF THE DISEASE

In most highly organized countries of the world, a neoplastic lump, particularly in an exposed position, excites, almost reflexly, reactions both in the patient and doctor which lead to its early removal. The natural course of the disease is thereby of course destroyed, and one is left for its assessment with the exceptional cases that refuse all treatment or delay treatment for many years. From examples of such cases one may say that a mixed parotid tumour may exist for many years without causing trouble apart from the deformity associated with a gradual increase in size. Sometimes the increase in size is very slow; thus, I have removed a parotid tumour from a woman aged 52 which in spite of its having been present for 32 years measured only 2 in. by 1 in. after removal, and I have seen other similar cases. On the other hand, increase in size may sometimes be much more rapid. It is probable that the cases which escaped active treatment in highly organized communities paint too favourable a picture of the course of the disease without treatment in that rapidity of growth and deformity naturally lead patients to demand treatment earlier. For this reason, a paper by Chen and Loucks is particularly important in that it deals with China, which may be regarded as less highly organized from the medical standpoint than the Western and American nations, and the people of which it may fairly be inferred are less likely both from opportunity and personal factors to demand early surgical treatment. These authors report 25 cases of mixed parotid

tumours, the average length of history of which before the patient applied for treatment was 11½ years. In the case with the longest history the tumour had been growing for 37 years. Among the illustrations to the article there is a photograph of a patient with a tumour which one would judge to be about the size of a clenched fist after only 5 years' growth, one of another tumour about the size of two clenched fists after 30 years, and one of another which after 21 years looks almost as big as the patient's head. Presumably the authors specially picked these cases for photographic reproduction, and they comment on the widely differing rates of growth in different individuals, noting that in some cases the development is slow. They also comment, as do other authors, on variations in rate of growth in the same tumour. It is, in fact, not uncommon for patients who present themselves for treatment after the tumour has been growing some time to say that the thing which finally brought them is that they think the tumour had recently been growing more quickly. But how much reliance can be placed on this impression is in many cases difficult to determine. McFarland gives the average rate of growth as up to the size of a walnut in 10 years, and an orange in 20 years. Further cases of long history of parotid tumours without treatment have been recorded by Martin, histories being recorded of 42, 35, 21, 20, 15, 15, 13, and 10 years. The natural history of the disease, therefore, which patient and doctor may anticipate if no active treatment is adopted is a gradual increase in size of the tumour, which in one case may be so slow that after 30 years the deformity is negligible, and in another case may result in an unsightly deformity in a few years.

The Question of Spontaneous Malignant Change.—A very important question is the risk of complications, particularly of spontaneous malignant change, during the course of this gradual increase in size. It has frequently been asserted, chiefly as a justification for early surgical intervention, that such spontaneous malignant change is common. Findeisen, and Moutier and Redon, are among the recent writers who have supported this view, though neither quote any evidence in support of it. On the other hand, Ahlbom, after an analysis of a big series of cases, states that at the Radiumhemmet they have never seen a histologically benign salivary tumour become malignant. Hybbinette goes a little further in saying that while malignant transformation may occur, it must be exceedingly rare. McFarland, in an article published in 1926, denied that carcinomatous change in a mixed parotid tumour occurred, but in a more recent article he takes the view that all mixed tumour irrespective of histological structure are potentially malignant, though such malignant potentialities are unlikely to become manifest apart from surgical intervention. Some of the confusion surrounding this question is due to a mixing up of two quite separate possible processes. In the first place, it is theoretically possible for a mixed tumour to change its histological type and become converted into a squamous-celled or glandular carcinoma; and secondly, it is possible for a mixed tumour to take on malignant characteristics without change of histological type. The chief evidence for the first process is the occasional occurrence of cases in which a carcinoma of the parotid develops on an apparently innocent lump. For example, in 1931 a man aged 54 was admitted to the Middlesex Hospital with a carcinoma of the parotid and associated facial paralysis. He stated that it had developed from a lump which he had had in the same region for from 10 to 15 years. In a case such as this it is an obvious possibility that the original lump was a mixed tumour. But microscopical examination, though showing a typical carcinoma, showed no evidence of any

underlying mixed tumour. Maggi describes a similar case, in which he claims to demonstrate evidence of the original mixed tumour, but the microscopical pictures he gives are not convincing. In fact, I know of no reported case of carcinoma of the parotid in which the evidence is complete that it developed from a mixed tumour, though it may justly be argued that the carcinoma may destroy the evidence of its origin. This type of possible malignant change in a mixed tumour must therefore be regarded at present as non-proven.

The other type of possible malignant change—the taking on of characters of malignancy, particularly in the form of widespread local infiltration without change of histological type—is well established. It is in fact the most important complication of surgical removal of mixed parotid tumours, as will be discussed later. But as a spontaneous process in an untouched tumour it must be extremely rare. A review of the records of the Middlesex Hospital since 1919 provides no example, and a study of the literature confirms its rarity. The conclusion seems justified, therefore, that while spontaneous malignant change in untouched mixed parotid tumours may occur, its occurrence is so rare that for practical purposes it may almost be dismissed.

Other complications during the natural course of mixed parotid tumours are only of very slight significance. Chen and Loucks noted that in 5 of their cases there was ulceration of the overlying skin, but in all these cases unskilled and primitive treatment by needling or plaster had been given. Normally, the striking thing is how little tendency there is to ulceration of the skin in spite sometimes of very large tumours. Occasionally patients complain of pain in the tumour, but it is rarely severe.

THE COURSE OF MIXED PAROTID TUMOURS FOLLOWING TREATMENT

The standard treatment of mixed parotid tumours has in the past been purely surgical, the standard operation being enucleation of the tumour. While after this procedure many, and probably even a majority, of the patients remain well for prolonged periods and are apparently cured of their disease, in too high a proportion of cases to be regarded with equanimity recurrence occurs, in some cases leading directly to the death of the patient. This subject was discussed in the writer's previous paper, and some of the further evidence which has since accumulated will be briefly referred to here. Stein and Geschickter, from a follow-up for varying periods of 104 cases from the Johns Hopkins Hospital, found recurrence in 20. Ahlbom concluded after analysis of the literature that from one-fifth to one-quarter of mixed tumours treated by surgery alone recurred within three years. Cogniaux and Simon, from their experience in a Belgian anti-cancer irradiation centre, state that they are appalled at the frequency of bad results from surgery, though in their position they are likely to see an undue proportion of such results. McFarland has written a further important paper, in which he showed that out of 297 tumours (278 of which were of the parotid) 69 or 23·3 per cent recurred and 13 proved fatal. He emphasizes the importance of following-up for prolonged periods owing to the possibility of late recurrence. Two of the cases discussed in the writer's previous paper as examples of local infiltrative recurrence have since died of the disease (*Cases* 43 and 32). The literature confirms previous conclusions

that the predominant type of recurrence is local, either encapsulated or infiltrative, but also shows that rarely lymphatic metastasis may occur, and also, exceptionally rarely, blood-borne metastasis. Thus, of McFarland's 69 recurrences, 3 showed lymph-node invasion and 1 metastasis to the lung.

Comparing, therefore, the natural course of the disease with that following surgical removal, it seems a fair conclusion that, while an untouched mixed parotid tumour will gradually increase in size and may eventually cause most unpleasant deformity, the chance of being killed by the tumour is slight; but that following surgical removal the patient may be cured of the disease, but at increased risk of being killed by it.

THE VARIOUS FORMS OF TREATMENT

The Fundamental Problem.—The fundamental difficulty in the treatment of mixed parotid tumours depends on a combination of pathological and anatomical factors. The anatomical difficulty is the position of the parotid and particularly its relation to the facial nerve. The chief pathological difficulty is that whereas the mixed tumours appear to be simple encapsulated tumours, such encapsulation is often incomplete. Sometimes it is so incomplete that the fact soon becomes obvious during attempts at operative enucleation. And based on this factor, Ahlbom divides the mixed tumours into semi-malignant and benign, the former being incompletely encapsulated, the latter encapsulated and enucleable. But it is now well recognized that even an apparently completely encapsulated tumour may show microscopically the presence of growth cells in the normal salivary gland outside the main tumour. Such deposits are best seen in mixed tumours of the submaxillary gland in which the whole gland is usually removed with the tumour. I operated on a case of this type in 1931, the patient being at the present time, 8 years after the operation, alive and well. But had this tumour been situated in the parotid gland, it would almost certainly have been treated by enucleation, and the infiltrating columns of growth cells in the surrounding apparently normal gland would have been left and would have furnished a potential source for future recurrence. From the pathological point of view, therefore, there are three rational lines of treatment. In the first place, the tumour may be left completely undisturbed to follow its natural course, which has already been discussed. Secondly, an operation may be performed which removes not only the obvious tumour but also any surrounding seedlings; and thirdly, the main tumour may be removed surgically by enucleation, the potential seedlings being dealt with by other means. All three courses have been suggested and carried out, and their advantages, disadvantages, and results will next be discussed.

EXPECTANT TREATMENT

Chief credit for emphasizing this aspect of treatment belongs to McFarland. As already noted, as the result of an extensive follow-up of cases after surgery, he was chiefly impressed by the disquieting frequency of recurrence, sometimes many years after operation. And from this experience he cast considerable doubt in the case of mixed parotid tumours on the correctness of the surgical maxim that a tumour should be removed at the earliest possible moment. In actual fact he found that recurrence was more common following removal of small mixed parotid tumours

than large, and he advocated that if surgery is carried out, it is better to wait before doing so until the tumour is the size of a lemon. Unless therapeutics can devise other means of dealing with the problem, McFarland's facts and arguments justify a more expectant attitude on the part of surgeons towards mixed parotid tumours. It must be admitted, however, that such an attitude is far from ideal, since it not only confesses a failure in treatment, but also may leave the patient with a most unpleasant deformity. For this reason most surgeons still aim at a solution by active means. But as a practical application of McFarland's arguments two conclusions seem justified: first, that in any mixed parotid tumour it is wise to avoid active surgical treatment for a time to see how rapidly the tumour is growing; and secondly, that in mixed parotid tumours first appearing late in life, in many cases active surgical treatment may be avoided altogether. Another point of importance in the expectant treatment of mixed parotid tumours is that of the accuracy of the diagnosis apart from exploratory confirmation. And it must be admitted that there are many conditions which may cause difficulties in diagnosis. Thus I have myself seen difficulties arise with simple lymphadenitis, tuberculous glands, lymphosarcoma and other primary lymphatic lesions, a secondary carcinomatous gland, and a branchial cyst. As the above list indicates, most of the conditions are lymphatic, and a slowly growing lymphatic gland actually in the substance of the parotid salivary gland is clinically indistinguishable from a mixed tumour. The rather rare adenolymphoma of the parotid is quite indistinguishable from a mixed tumour without microscopical examination. This question, therefore, of the difficulty in making an absolute diagnosis clinically is one that must be given full weight in deciding to treat an apparent mixed tumour expectantly. Occasionally the response to X-ray therapy may be a useful diagnostic test, since some of the simulating lymphatic conditions are radiosensitive, and, as will be seen later, such a course is not without possible advantages in a mixed tumour.

RADICAL REMOVAL

Dissatisfied with either the theoretical basis or the results of enucleation, some surgeons have advocated and carried out more radical measures for mixed parotid tumours. But there is a certain amount of muddled writing on the subject. Thus, some writers advise that after the tumour has been enucleated, the surrounding capsule should be removed. But after enucleation, the tissue left is normal parotid gland. There are three possible planes in which a parotid tumour may be removed. In the first place, the rather delicate capsule may be opened and the contained tumour tissue expressed. After this has been done, an attempt may be made to remove the capsule. While this method of removal may sometimes be forced on the surgeon by the rupture of the tumour during attempted enucleation, and under certain conditions has even been elevated to an advocated technique of removal by Hybbinette, from the pathological standpoint it has obvious gross weaknesses. Secondly, the tumour may be enucleated in the layer of loose alveolar tissue which lies between it and the surrounding normal salivary glandular tissue. This is the type of surgical removal which is usually aimed at, but, as already pointed out, even if successfully achieved, recurrence may still occur owing to the leaving behind of microscopical seedlings. Finally, the tumour may be removed with a margin of surrounding salivary glandular tissue by cutting through or outside the gland. This

procedure involves almost of necessity the cutting of some or all of the branches of the facial nerve, depending on the amount of gland removed. There is no doubt that a radical removal of this type is the operation with the soundest pathological basis, and it is the operation which is carried out as a routine in the case of the submaxillary salivary gland. But for most patients and surgeons the disadvantage of facial paralysis weighs too heavily against even its pathological soundness. Nevertheless, some surgeons, chiefly of the French school, recommend the routine performance of this type of operation. Duval and Redon describe an operation of subtotal removal of the gland in which the lower part of the gland and the lower branches of the facial nerve are removed, and the upper branches of the nerve preserved; and they quote 5 cases. Cadenat describes a similar type of operation in which at the same time the anterior belly of the digastric is transplanted in an attempt to remedy the lower facial palsy. Cogniaux and Simon, however, criticize Duval's operation owing to the resulting deformity, and state that his original case recurred seven years after operation. A further criticism might be made in that in tumours situated in the upper part of the parotid gland it is probably impossible to preserve the upper branches of the facial nerve without offending the principles of the operation. Saltzstein describes a case in which the whole parotid gland is stated to have been removed for a mixed parotid tumour with preservation of the facial nerve, but again it is difficult to see how such a conservative operation could be carried out without encroaching on its pathological completeness. I have never yet attempted complete removal of the parotid gland for a mixed tumour, as I agree with the general surgical opinion that such an operation as a routine is too deforming. I have had one case, however, in which I considered the operation, turned it down, and afterwards regretted my decision. The patient was a man aged 52, who 25 years previously had had a mixed parotid tumour removed, and who when I saw him had a local recurrence which operative exploration soon revealed was infiltrating the gland. After careful deliberation, I chose as treatment incision and scraping out of the tumour mass combined with buried radium and post-operative superficial irradiation. The patient died three years later with local recurrence and probable intracranial extension. In cases such as this, in which development of local infiltrative recurrence indicates that the position has become serious, if the recurrence is confined to the parotid complete removal of the gland and the associated complete facial palsy seem a justifiable price to pay for an increased chance of eradication of the disease. And a similar conclusion might also hold as an exceptional measure in certain primary cases in which gross infiltration is obvious.

IRRADIATION

Dissatisfaction with the standard surgical treatment of mixed parotid tumours has naturally led to an exploration of the possibilities of radiotherapy. But as a primary and sole method of treatment, radiotherapy has not proved satisfactory. To quote three recent authorities: McFarland states that he finds no substantial evidence of radiation being of any benefit; Ahlbom states that the experience of the Radiumhemmet is that the tumours vary from only slightly radiosensitive to radioresistant; while Hybbinette comes to similar conclusions. Hybbinette analysed the results in 22 cases in which mixed tumours were irradiated as a preliminary to surgery. In no case was any striking effect noted, and in 13 the size

was apparently unaltered. Moreover, in 1 case in which eighteen months elapsed between the irradiation and operation, the tumour had again started to increase greatly in size. In 1934 and 1935 I investigated this same question in collaboration with Mr. Windeyer of the Meyerstein Institute of Radiology, Middlesex Hospital. Five successive cases of mixed parotid tumour were given full courses of external irradiation, either by means of the 1-g. radium unit or by high-voltage X-ray therapy. In addition a further case was treated by irradiation in the mistaken diagnosis of a tuberculous gland. All six cases were eventually operated on, but the operation was not carried out till some months later so that the full effect of the irradiation could be noted. Accurate measurements were made of the tumours before and after treatment. In no case was there anything more than a negligible reduction in size. Moreover, in one case in which there was no obvious effect from the irradiation, the patient refused further treatment for three years, when he came and asked for the tumour to be removed, as it was getting bigger. I have myself had no experience of buried radium as a primary treatment of mixed parotid tumours, but there was a further case under the care of a colleague in which the diameter of the tumour is noted as having been reduced in size from 5 cm. to 3·5 cm. as a result of combined external irradiation and buried radium. At the end of a year, however, this patient too came to operation.

As a qualification, however, of the above conclusions on the effect of irradiation on mixed parotid tumours, it should be pointed out that occasionally infiltrating mixed tumours are met with that are extremely radiosensitive. A striking case of this kind was quoted and illustrated in the writer's previous paper, and other similar cases have been seen. The experience of the writer has in fact been such as to leave the impression that in large part the degree of radiosensitivity of the mixed tumours depends on their relation to the surrounding tissues; if the tumour tissue is infiltrating the surrounding tissues it may be radiosensitive, if it is encapsulated it is radioresistant.

The Histological Effect of Irradiation.—Microscopical sections of 6 of the above-noted 7 cases were available for study, and also a section of a more recently treated case. The striking thing microscopically about the tumours was the large amount of mucinous tissue present. As a control, the microscopical sections of the 7 irradiated cases were compared with 7 consecutive recent sections of mixed parotid tumours which had not been irradiated. The degree of mucinous change in each section was classified as from 4 to 1, 4 representing a high degree of mucinous change and 1 a low degree. On this basis the writer classified the radiated cases as 3, 4, 4, 4, 3, 2, 4, and the control cases as 2, 2, 2, 2, 3, 1, 2. Dr. R. W. Scarff, of the Bland-Sutton Institute of Pathology, kindly made an independent classification of the same sections with the following result: irradiated cases 4, 4, 4, 4, 3, 2, 3, and controlled cases 1, 3, 2, 2, 4, 1, 2. While there are naturally slight individual differences in the two classifications, both agree in noting the high degree of mucinous change in the irradiated cases as compared with the controls. It is well known that mucinous (pseudo-cartilaginous) tissue is a normal feature of mixed tumours, in some cases being present in considerable amounts. And in the present series no sections were taken of the tumours before irradiation as it was not felt to be justifiable from the therapeutic standpoint to cut into an encapsulated tumour. It is therefore possible that the present series represents the chance occurrence together of mixed tumours showing extensive mucinous change. But the possibility of the change being the

result of the irradiation definitely arises, and should be borne in mind for future investigation. In this connexion, the writer was interested to read the following remarks in the French summary of a recent Russian work on salivary tumours by Zymbal: "Nos observations sur la transformation de la structure des néoplasmes des glandes salivaires à la suite du traitement nous permettent de faire quelques reflexions sur l'origine de ce genre de tumeurs. C'est ainsi qu'une tumeur, formée d'abord par des masses cellulaires compactes, a pris à la suite de la curiethérapie les caractères d'une reticule à substance intercellulaire abondante, prenant la coloration metachromatique."

A COMBINATION OF SURGERY AND IRRADIATION

For most surgeons the combination of irradiation with surgery has during the past decade or so seemed to provide the most hopeful and practical means of overcoming the disadvantages of surgery alone. Sufficient time has now elapsed for a preliminary assessment of this combined treatment to be made. It may, however, be many years before a final assessment is possible. A minority of surgeons have experimented with pre-operative irradiation. Hybbinette, from his experience in the series of cases already quoted, gives as an additional argument in favour of this course that it toughens the capsule of the tumour. When I read this argument of Hybbinette's, I looked up the operative histories of my own 6 cases that had had pre-operative irradiation, and found that all had been enucleated without rupture. As a control, I found that out of 31 consecutive primary cases of mixed parotid tumour treated at the Middlesex Hospital, 9 were noted as having ruptured during removal. The claim that the capsule is toughened by pre-operative irradiation therefore seems worthy of further investigation.

Most surgeons who have adopted the combined treatment have used post-operative irradiation, either X-ray therapy or the heavy radium unit externally, or, more commonly, buried radium in the operative wound. As to results, Ahlbom states that out of 90 benign mixed tumours treated radiosurgically, a small number of which were not in the salivary glands, 85 were free of symptoms and signs after periods varying from 2 to 21 years, though in 5 of these recurrence had occurred and been successfully treated. While out of 33 semi-malignant tumours treated radiosurgically, 29 were free of symptoms and signs and 4 were dead, 2 directly as the result of local infiltrative recurrence. Two of the 29 cases that were alive had had recurrences which had been successfully treated. Fitzwilliams, without giving detailed figures, states that a heavy dose of buried radium after operation almost abolishes risk of recurrence. At the Middlesex Hospital, from 1919 to 1936, 23 primary cases of mixed parotid tumour were treated by a combination of surgery and irradiation. Most of the cases have been treated since 1930; before that time only the occasional case had the combined treatment. Two of the earlier cases have not been traced at all since the operation, and one case after remaining well and without recurrence for five years was then lost track of. The remaining 20 have been traced up to July, 1939. Of these 18 are alive and well, have developed no recurrence, and are at present free of recurrence. The time that has elapsed since operation is in 1 case twelve years, in 1 case nine years, in 4 cases eight years, in 1 case seven years, in 3 cases five years, in 6 cases four years, in 1 case three years, and in 1 case two years. (The last case was the one already mentioned which refused further treatment for three years after his initial radiotherapy.) Of the remaining

2 cases, 1 developed a small nodule in the scar four years after operation; this was excised, but unfortunately not examined microscopically, and since that time he has been quite well, the time that has elapsed since the original operation being thirteen years. The other case is still alive six years after operation, but has in the meantime been treated for two recurrences, and is at present under observation with suspicion of recurrence. This last case is of particular interest as the only fully proven case of recurrence in the series. It was a woman aged 66 who in 1933 had a tumour 1½ in. in diameter removed from the right parotid, the notes stating that it "shelled out easily". And yet in spite of this and the post-operative irradiation with the 1-g. radium unit, the case has followed a recurrent course.

On the negative side, therefore, it may be concluded that even an operation which is technically satisfactory, and followed by the most modern forms of radiotherapy, does not guarantee freedom from recurrence. On the positive side, it is still much too early for final conclusions. The occasional development of late recurrence many years after operation has already been mentioned as well known, and it is possible that a review of this same series of cases in a few years' time would furnish quite a different picture. But within its limits, this series of cases compares favourably with any recorded series of cases treated by surgery alone. It seems a justifiable interim conclusion, therefore, that the addition of radiotherapy to surgery is on present evidence advantageous.

CONCLUSIONS

As a result of this analysis the present position of the treatment of mixed parotid tumours may be summarized briefly by the following statements, some of the dogmatism of which it is hoped will be regarded as diluted by the discussion and qualifications in the text of the article:—

1. The natural course of mixed parotid tumours is to increase in size at varying rates, leading to a corresponding degree of deformity, but otherwise causing very little disability.

2. Spontaneous malignant change in a mixed tumour is so rare that for practical purposes it may be ignored.

3. Surgical enucleation alone may be satisfactory, but in too high a proportion of cases to be regarded with equanimity recurrence occurs, and in some cases such recurrence leads directly to the death of the patient.

4. There should be no hurry to treat these tumours. A period of observation to determine the rate of growth may be advantageous.

5. In mixed parotid tumours appearing late in life, and in slowly growing tumours appearing earlier, the correct treatment may be to do nothing.

6. Radical excision of the parotid is too deforming to be a routine treatment of mixed parotid tumours. There may, however, be exceptional cases in which it is the correct treatment, and in which the price of complete facial palsy is a justifiable one for the patient to pay.

7. Irradiation alone is not a satisfactory form of treatment. It may, however, be a useful diagnostic measure.

8. Pre-operative irradiation is valuable since it renders the capsule of the tumour tougher and less liable to rupture during operation.

9. Enucleation followed by irradiation is on present evidence the best active treatment for mixed parotid tumours.

REFERENCES

AHLBOM, H. E., *Acta radiol*, 1935, supp. 23.
CADENAT, F. M., *Jour. de Chir.*, 1936, **48**, 625.
CHEN, H. I., and LOUCKS, H. H., *Chinese Med. Jour.*, 1933, **47**, 138.
COGNIAUX, P., and SIMON, S., *Jour. de Chir. et Ann. Soc. belge de Chir.*, 1937, **36–34**, 152.
DUVAL, P., and REDON, H., *Jour. de Chir.*, 1932, **39**, 801.
FINDEISEN, L., *Deut. Zeits. f. Chir.*, 1937, **248**, 590.
FITZWILLIAMS, D. C. L., *Lancet*, 1935, **2**, 769.
HYBBINETTE, S., *Acta. chir. Scand.*, 1935, **77**, 19.
MCFARLAND, J., *Surg. Gynecol. and Obst.*, 1936, **63**, 457.
MCFARLAND, J., *Amer. Jour. Med. Sci.*, 1926, **172**, 804.
MAGGI, N., *Arch. ital. di Chir.*, 1937, **47**, 363.
MARTIN, T. M., *Arch. of Surg.*, 1938, **36**, 136.
MOUTIER, F., and REDON, H., *Jour. de Chir.*, 1933, **41**, 44.
PATEY, D. H., *Brit. Jour. Surg.*, 1930, **18**, 241.
SALTZSTEIN, H. C., *Ann. of Surg.*, 1936, **103**, 635.
STEIN, I., and GESCHICKTER, C. F., *Arch. of Surg.*, 1934, **28**, 492.
ZYMBAL, W., *Les Tumeurs des Glandes salivaires*, 1938, 281. Leningrad : State Oncological Institute.

LUNG INJURY IN THE INTACT THORAX WITH REPORT OF A CASE

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Lung injury in the intact thorax—apart from a few isolated cases—has found little mention in English surgical literature. The possibility of its occurrence, however, is familiar to most surgeons, especially after the experiences gained in war, and in the ever increasing variety of civilian injuries. There are nevertheless many instances in recent literature of failure to diagnose lung rupture when it existed: in none of the 4 fatal cases described by Villegas and de los Angeles was a diagnosis of lung rupture made, and in recent books dealing with athletic injuries there is no mention of this form of trauma.

It can be assumed that the trauma has been applied to healthy lungs, as it is well known how easily lungs affected with tuberculosis and other lesions give way—sometimes indeed spontaneously. It must be accepted also that there is a group of cases of pneumothorax due, with or without the aid of trauma, to rupture of superficial blebs, bullæ, or cysts, which, according to Gordon, cannot often be demonstrated during life. Again, the literature presents several cases of rib fracture or dislocation associated with lung injury (Lamballe, Nankivell, du Séjour, and others), but as there is often no local lesion, e.g., pleural tears, or pleural or lung contusions, these fractures or dislocations must be regarded as coincidental and not causative.

The occurrence of this type of injury was recognized and described as early as 1761, when Morgagni reported the post-mortem findings in two cases. Schwartz and Dreyfus gave a good account of the condition and a review of the literature in 1907, and Fischer wrote an excellent monograph in 1912.

The first recorded case in English is probably that of R. W. Smith, of Dublin, in 1840. A few points from his notes are interesting: "A man of large size was knocked down by the Inniskillen Mail which passed over his body. He was admitted to hospital with intense dyspnœa and extreme emphysema at the root of the neck and chest wall. There was no hæmoptysis and he died in three-quarters of an hour after admission. Post-mortem examination showed collapse of the right lung with extensive pneumothorax. There was a large quantity of blood around the roots of the great vessels and aorta. There were three separate lacerations in the substance of the right lung, but no tear of the pleura was demonstrated. There were no fractured ribs." Smith described three other personal cases, one being of a dog over whose body a carriage had passed. Examination of the body showed no fractured ribs, but extensive lacerations of a lung.

Many of the cases reported were the result of severe crushing violence to the chest and the diagnosis was usually not made until post-mortem examination. The diagnosis in the following case, occurring after comparatively mild trauma, was suspected clinically, and confirmed by X-ray examination.

CASE REPORT

Feb. 3. Mr. L. O'K., a medical student, aged 24, was representing his University in a novices' boxing contest. He was 'down' on three occasions, once for a count of seven, and lost his fight. One hour afterwards he felt sore in the small of his back and thought he had 'pulled' a muscle. He did not feel well and went to bed, but pain kept him from sleeping well. Hiccup, which occurred once or twice, increased the pain.

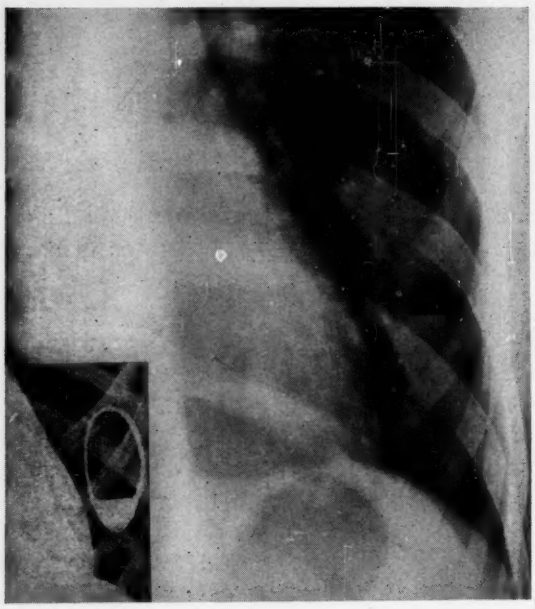

FIG. 32.—Radiograph, February 7, 1939, four days after injury, showing cavity containing fluid in left lower lobe.

Feb. 4. His chest was strapped, making him feel easier.

Feb. 6. He coughed up some dark blood-clot. He was "too terrified" to cough again, as he thought he could bring up more. It was at this stage that I saw him. His physique was slight, but of average muscular development. Physical examination revealed nothing except some bruising over the left lower ribs in front. Examination of the lungs was negative. I suggested that an X-ray examination of his chest should be made the next morning.

Feb. 7. More dark blood-clot was coughed up. A radiograph (*Fig.* 32) showed a cavity containing fluid in the lower lobe of the left lung. No air or fluid was present in the pleural cavity.

Feb. 8. Some more dark blood-clot was again coughed up. Examination of the chest by a physician showed no abnormal signs except that the left side moved a little less than the right. His blood sedimentation-rate was 9 mm. in 1 hour. A radiograph of the chest (*Fig.* 33) showed that the cavity was slightly smaller and the amount of fluid less.

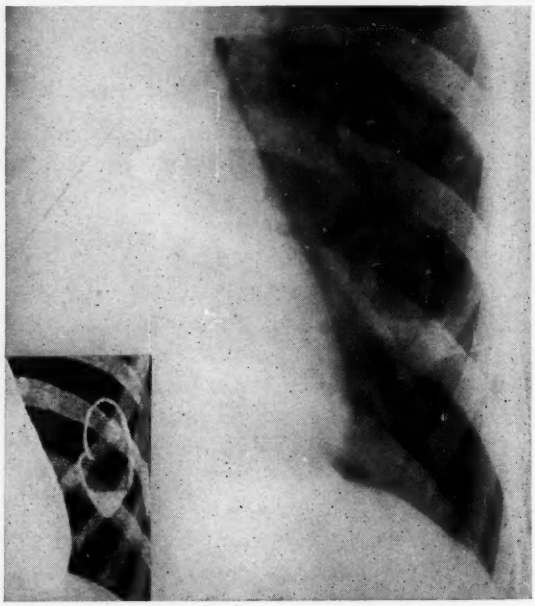

FIG. 33.—Radiograph, February 8, 1939, five days after injury. The cavity is slightly smaller and the amount of fluid is diminished. Partly obscured by strapping.

Repeated screening examinations of his chest were carried out at this stage, and the cavity was shown to be approximately central in position in the lower lobe. I was assured by my radiological colleague that no pneumothorax or hæmothorax was present; paracentesis thoracis was considered unnecessary. He was confined to bed, much against his will, for the succeeding week. No further hæmorrhage occurred, but yellowish-green sputum was coughed up freely. His blood sedimentation-rate was normal in a week. Eleven days after injury the cavity was much

smaller in size and the fluid had gone. Eighteen days after injury the cavity was barely distinguishable. No complication followed and he returned to work and has remained in excellent health. A recent radiograph in December, 1939, shows no abnormality in the left lung.

MECHANISM OF INJURY

Injury to abdominal organs is usually direct, as the soft abdominal wall offers little resistance, but in thoracic injuries the mechanism is not quite so simple. R. W. Smith pointed out long ago the resemblance of these injuries to laceration of the brain after concussion without a fracture of the cranial bones, and Sellors recently sums up as follows: " Injuries of the chest are to a certain extent comparable with those of the abdomen and skull, in which attention is concentrated less on the parietal lesion than on the possibilities and extent of damage to the contained viscera."

Most writers are agreed that injury to the thoracic viscera is much commoner in children and in adolescents, and that it is due to the elastic nature of the thoracic cage. Payne is alone in maintaining the opposite view when he states, " If the ribs are soft and pliable as in young people they are less likely to fracture, but as they bend the force expended in bending them is absorbed and therefore does not easily pass through and injure the lung ".

Most writers suggest that the lung is simply compressed by the resilient ribs against the vertebral column; with this view Sydney Smith agrees, though be adds, " there is no positive evidence (bruising of the bone) to support such a view ". This would explain the frequency of injury to the lower lobe, which forms the great mass of the lung and often shows a vertical tear.

The diminution of the thoracic cage as the immediate result of trauma begins to show itself first at the expense of the mobility of the costovertebral and costosternal joints; indeed, as in the cases of du Séjour and Schwartz and Dreyfus, the costosternal joints may even partially dislocate. A moment comes when mobility of joints is not sufficient, and then, as Limón and Pera state, a new factor intervenes which is ruled by the elastic properties of the costocartilaginous cage.

Triepel, in a series of experiments on the thorax after removal of the viscera, showed how much compression can be applied before actual fracture occurs. In the young thorax the sternum can be compressed against the vertebral column without a fracture resulting. In older subjects the approximation is much less. Testing the minimum loading weights which will cause fracture or a separation of the cartilage from the sternum, he made the interesting observation that a man's thorax can take more lateral pressure and a woman's thorax more sagittal pressure. He recognizes, however, that only a small part of the force falls on the bones, as the living subject can suffer three to four times greater loading force than was applied in his experiments.

In this connexion also the animal experiments of Klubs are interesting. This author found that blows delivered on the anterior and anterolateral aspects of the chest wall caused injuries to the underlying lung more extensive and more numerous than blows from the back on the lower lobe. The explanation he gives agrees with the above observations. The chest yields more to a blow from the front and is less capable of resistance as a whole.

A *contre-coup* effect also was noticeable only after an anterolateral blow, and in a long series of experiments was never seen following a blow on the lower lobe

from behind. Klubs admits that the greatest reserve is necessary in applying these conclusions to man.

The presence of air in the lung itself at the time of injury is of primary importance. This was pointed out by Gosselin, who stated that compression of the air in the lung caused instinctive closure of the glottis, thus making it impossible for the pulmonary sponge to empty. The lung then bursts as a solid mass, like the spleen or liver. Courtois, however, failed to confirm this experimentally when he inflated healthy lungs and submitted them to abrupt compression. When the upper respiratory tract remained free the lungs were not damaged; but every time a ligature was placed on one of the large bronchi tears resulted. Spasm of the glottis, although often cited as a factor in causing tearing of the lung, has not been satisfactorily proved to act in this way. It seems to me unlikely that the vocal cords could effectively obstruct the egress of air. As Schwartz and Dreyfus point out, however, spasm of the glottis may be present and augment the lesion.

Peyrot stresses the anatomico-physiological arrangement of the pleura. The normal cohesion of the pleural surfaces holds the lung to the parietes, and if the chest wall with its parietal pleura (and the lung with its visceral pleura) is depressed, the rest of the lung is prevented by its natural adherence to the chest wall from following the movement. A part of the organ which is seldom stretched is thereby straightened out and tears result. This Peyrot refers to as "direct injury" to the lung; "indirect injury", on the other hand, he explains less easily. Considerable changes in shape due to compression separate momentarily two opposite parts of the lung, each held to the thoracic wall by the pleural adherence-traction exercised on the lung tissue, which may result in tears, the site of which may be more or less distant from the point of force—"*le mécanisme de l'arrachement*".

Du Séjour agrees that the above mechanism would explain rupture if the pleura were adherent, but thinks that otherwise there is too much gliding between the pleural surfaces, and does not agree that there could be sufficient traction between the depressed part and the part that does not follow the movement to tear the organ. In his opinion the lung filled with air at the time of trauma is abruptly compressed, and escape of this air through the upper air-passages is insufficient, hence a rupture by sudden compression as one might burst an inflated paper bag—"*éclatement par compression*".

This 'bursting mechanism' is accepted by Limón and Pera, but for partial ruptures they have a slight modification. The lung considered diagrammatically is constituted of a series of lobules, each one being suspended by a small tube which in turn is linked up to a larger connecting tube. If a broad surface of the organ is suddenly compressed, some of the primary tubes are closed off from the principal connecting tubes, and owing to the pressure they rupture the lobule to which they are attached.

Among the causes of these injuries are:—

Run over by heavy vehicle. This is by far the most common cause. (It occurs in 22 out of 70 cases in Fischer's series.)

Fall from a height.

Blows on the chest.

Glancing blow of a bullet (Rees).

Nearby explosions.

Lifting a child by the arms (Cockle).

Increase in the intrapulmonary pressure:

Coughing as in whooping-cough and in induction of anæsthesia (Sauerbruch).

Coughing in debilitated children (Stransky).

During labour (Cunningham).

Dyspnœa during tracheotomy operation (Werwath).

Violent respiratory effort (Waters).

Joannides and Tsoulos, after experimental work on the production of mediastinal emphysema in dogs, came to the conclusion that " anything which produces an increased intra-pulmonary pressure, such as a severe cough, child labour, lifting of heavy weights, etc., probably causes a mild degree of mediastinal emphysema and air embolism, which as yet we have no way of recognizing clinically ".

In cases of severe injury we often find lung rupture associated with rupture of other internal organs, such as brain, liver, spleen, kidneys, and heart, without any damage to the parietal structures (Villegas and de los Angeles; Cunningham; Wharry; and others). Both lungs were injured in the cases described by Laurent and Waters. The phrenic nerve has been reported ruptured in nine of MacKenzie's cases. Fracture or dislocation of the clavicle as an associated injury is noted by Widerøe, Rees, Davison, Mollard, and S. Smith. Traumatic asphyxia was also a feature in Davison's case of lung rupture.

MORBID ANATOMY

The extent of the internal injury is proportionate, in the first place, to the causative violence. The morbid anatomy of the injuries varies greatly. As Overholt justly remarks, " the fact that we have air sacs with communicating bronchi, blood-vessels, and the potential pleural space so intimately connected frequently results in very bizarre and variable conditions ".

In simple contusion bleeding occurs into the lung substance. It may be peripheral—that is, subpleural and corresponding to the area of trauma—or it may be central in position. Not uncommonly, as Duval pointed out, we find areas of contusion at the base and apex of the injured lung, with blood infiltration of varying extent—simple contusion by *contre-coup*. Duval demonstrated even small tears of the visceral pleura on the opposite side. Martin has also demonstrated these *contre-coup* areas; they were shown by radiography as limited opacities in the lung.

These small subpleural hæmorrhages under both the visceral and parietal pleura were also a feature in one of the cases of Schwartz and Dreyfus. The affected lung sank in water. The case was one of bruising of the lung without any great tear of the organ, but producing what seemed to be multiple small bursts. Lamballe gave the following description of lung bruising:—

1st degree—a simple tear of the capillary vessels with production of ecchymosis;

2nd degree—more important vessels torn with real blood effusion;

3rd degree—the lung is more or less reduced to pulp in places with lesions of the larger bronchi and blood-vessels.

These small bursts of the alveoli explain in some cases the absence of real hæmoptysis, the slight reaction of the pleura, and, moreover, the considerable emphysematous bulging in the neck. Rupture of the alveoli with interstitial

emphysema about the capillary vessels was also noted recently in the animal experiments of Adams and Polak. (This was an attempt to simulate submarine escape lesions in man. They showed how the breath is held until the breaking point, or until overstretching and tearing of the alveolar walls result.)

Frequently the hæmorrhage is massive and may be localized to one lobe as in a case of Sauerbruch's, in which the patient subsequently developed gangrene of the lobe and a putrid empyema. It can be even more extreme, as in Rocher and Dupérié's classical case of gross hæmorrhagic infiltration of both lungs without apparent tears in the pleura. Like cases have been reported by Duval and by Laurent. Lilienthal quotes a striking example of a localized lung hæmatoma after a run-over accident which showed on radiography as a circumscribed shadow at the periphery of the lung. This author also had the opportunity of studying the radiological appearances of a lung hæmatoma during its development. Immediately following the accident the shadow on the radiograph was small and at the periphery of the lung. Three days later it was much larger and gave a general opacity, but on the ninth day this opacity had shrunk and at the same time become more clearly defined. A radiograph some time later usually shows some shadow indicating fibrosis, though Dieffenbach's case of interstitial hæmorrhage gave completely negative radiological findings ten days later. Santé gives an excellent account of the radiological appearances of lung hæmorrhages following trauma to the chest, and stresses the irregular blotchy areas of increased density about the site of injury, but adds, " without history of recent trauma and an indication of the prevailing symptoms the diagnosis could hardly be made from a radiograph ".

That hæmorrhages into the lung parenchyma occur was borne out also by Klubs in his experimental work on dogs. Hæmorrhages were noted from the livid appearance of the early case to the grey structure of organization five to ten days later. This writer showed also that a fibrinous pleuritis was common over the affected lobe. Fine pleural adhesions over contused areas were observed by Martin as early as nine hours after injury.

The grosser lesions of the lung consist of ruptures of varying types. Fischer gave a schematic classification of ruptures of the lung according to the severity and site of the lesion :—

1. Crushing into a shapeless mass of one lobe of the lung or of the whole lung.

2. ' Internal ' ruptures of the lung with intact visceral pleura. These may be either central or subpleural. (The case described above is a good example of this variety of injury. Almost identical cases have been described by Lamballe, Sourdille, and Sicard and Anastaze.)

3. Complete penetrating ruptures of the lung situated at : (*a*) The convexity of the lobe ; (*b*) The hilum ; (*c*) The interlobar part of one or more lobes ; (*d*) The border of adhesions ; (*e*) Parallel to the vertebral border, along the pulmonary ligament. This third variety is by far the commonest type of rupture met with in the literature.

4. Separation of one lobe of the lung, as is shown in Taylor's and in Scott's cases. The complete separation of the whole lung has been remarked upon by Sauerbruch.

More recently Cooke gave a good clinical classification of these injuries :—

1. *The Pneumothorax Type.*—A simple rupture of a few alveoli leading to pneumothorax and without evidence such as hæmoptysis or hæmothorax to suggest

extensive damage to the parenchyma. Pneumothorax following chest injuries is fairly common.

2. *Parenchymal Rupture.*—This is a simple rupture without laceration of the visceral pleura. On section the lung shows numerous hæmorrhages of any size from a pea to a walnut. These hæmorrhages completely disintegrate the lung tissues, giving the appearance of a cavity filled with blood. Neither pneumothorax nor hæmothorax is present, but, according to Cooke, hæmoptysis is constant and may be the only indication of lung damage. It should be noted here, however, that the absence of hæmoptysis has been a feature in the cases recorded by R. W. Smith, Kerr, Marsh, and Boutillier.

3. *Combined Type.*—The visceral pleura is torn and a hæmopneumothorax is present. This is by far the commonest type of lesion and numerous examples of it are recorded in the literature.

Tears of the larger bronchi have been known to occur, but are very rare. Davies believes that they occur when the compressing force on the chest (and consequently the rise in the intrapleural pressure) is at the time of onset unilateral. There is then a violent dislocation of the mediastium to the opposite side and a rupture of the bronchus on the same side as the lesion. The left side is affected more often than the right, and it has been suggested that the bronchus may be ruptured across the front of the vertebral column. Recovery is followed by traumatic stenosis, which may then be complicated by severe bronchiectasis. Thomas's case of a rupture of the right bronchus presented the mediastinum filled with a massive blood-clot, and blood was in both pleural cavities.

SYMPTOMATOLOGY

Shock is frequently present from the onset of injury, and varies in severity. In the *commotio thoracis* syndrome applied by Sauerbruch to severer forms of injury, there is no visceral damage, but collapse is marked. This is believed to be due to vagosympathetic stimulation.

Cough is almost always present, and is due to compression of the lung and to irritation of that organ.

Dyspnœa is also a frequent symptom and varies in intensity. When air or blood, or both, are under tension in the pleural cavity or mediastinum the dyspnœa may be alarming.

Hæmoptysis is also often present. It may be severer at the time of trauma and end fatally, or it may be delayed, as shown in Moore's and Sourdille's cases. The presence of dark blood-clot is very suggestive of lung damage. As already mentioned, several cases of lung rupture are on record in which the absence of hæmoptysis is a feature, including even Boutillier's case, where a large bronchus opened on the ruptured surface.

Hæmothorax deserves special attention. Whether it exists or not depends upon the extent and localization of the lesion. It may be entirely absent. Most fatal cases were found to have a large quantity of blood in the pleural cavities. Lockwood, who had extensive experience of lung surgery in the Great War, was much impressed by the constancy of hæmothorax, but he observes that rarely, if ever, has he seen bleeding from a contused or torn lung. Excision of a wound in the lung is accompanied by remarkably little hæmorrhage.

Santé has studied the radiological appearances of hæmothorax. In its full extent it may present a picture similar to ordinary pleural effusion—a dense homogeneous shadow obscuring the costophrenic angle and presenting a hazy curved upper border. Rarely are the mediastinal structures displaced—the patient could not afford sufficient blood for this to take place and survive. In Maffré's case the onset of hæmothorax was delayed and at post-mortem examination the heart was found to be at the right of the sternum and the left pleural cavity contained no less than six litres of blood. Santé has shown, however, that the picture is somewhat different in recent hæmorrhages. The escaping blood spreads itself out as a thin layer between the lung and the chest wall, causing a diffuse haziness of the entire side of the chest from the apex to the base. This shadow is not dense—ribs can be distinguished through it, and the costophrenic angle is not obliterated. The mediastinal structures are not displaced, and the appearance suggests consolidation of the lung. Santé and other workers emphasize that blood in the pleural cavity does not show the same tendency to clot as blood elsewhere, nor does it undergo organization and calcification. Fluid blood has been aspirated from the pleural cavity three months after injury, and this is not due to lack of air, since cases associated with pneumothorax do not show a greater tendency to clot. It is, however, well to recall Henry and Elliott's work during the Great War. These writers showed that blood flowing from lung wounds clots rapidly, but that this clotting is not a massive coagulation, as the cardiac and respiratory movements agitate the blood and cause defibrination. The fibrin is thrown down in layers on the lung and on the parietal pleura.

Pneumothorax is usually present in cases of lung rupture and associated with hæmothorax. It is often the cause of dyspnœa, and may be severe enough to cause marked displacement of the mediastinum and even downward displacement of the diaphragm. This downward displacement of the diaphragm, which in McDonnell's case was below the costal margin, produces severe abdominal symptoms, and has led to a wrong diagnosis and a laparotomy (Le Conte, Dieffenbach, and Mercadé).

The escape of air through a valve-like opening in the visceral pleura at each inspiration gives rise to a tension pneumothorax, which is a condition calling for rapid relief.

Mediastinal emphysema is an important sign when there is no rib fracture. The air is forced out at inspiration and traverses the peribronchial spaces until it reaches the mediastinum. That this mechanism is true is shown by the appearance of emphysema after rupture of the intrapulmonary bronchioles and without rupture of the periphery of the lung (Schwartz and Dreyfus). The air thus quickly ascends into the neck and presents itself as a globular fluctuant swelling just above the sternum—the *Wilms' phenomenon* of some writers. It may give rise to alarming pressure symptoms requiring immediate surgical intervention, or, on the other hand, it may gradually extend over a wide area.

Massive pulmonary collapse has been known to complicate lung injuries, particularly injury to the upper thorax (Deal), and is due to absorption of air behind large mucous plugs in the bronchi. This is well shown in two cases and specimens described by Brock, in which both main bronchi were found obstructed at post-mortem by thick viscid mucus. The accumulation and retention of these plugs is favoured by interference with coughing, by pain from bruising or fractured ribs, and by prostration due to the injury.

SEQUELAE

The damaged, blood-laden lung tissue offers poor resistance to infection, and there are many cases of resulting gangrene and lung abscess in the literature. Abscess is more common with central lesions. Gross gangrene of an entire lobe has already been mentioned. Hæmothorax is also prone to become infected and form an empyema. Traumatic pleurisy frequently develops at the site of injury and is more common than pneumonia. Contusion or traumatic pneumonia has been well described by Claisse, Payne, Santé, du Séjour, and Vaiss. The actual pneumonic process may develop any time from one to ten days after the injury and takes the form of lobar pneumonia. It may be on the same side as the injury or on the opposite side, or on both. There is no relationship between the severity of injury and the severity of the pneumonia, which also has a higher mortality than ordinary lobar pneumonia (Priboianu and Blechmann). Traube and Vulpain consider that the pneumonia is due to aspiration, the *Schluck-pneumonie* of the German authors, while Schiff thinks it is due to stimulation of the vagus nerve producing vasodilatation in the pulmonary field.

A relationship between injury to the lung and tuberculosis is difficult to establish, and it is still a medico-legal problem. It can be argued that the damaged area of the lung offers diminished resistance to tubercle bacilli, but Sergent saw only 9 cases of tuberculosis in 1400 cases of war wounds of the lung, and similarly de La Villéon in an extensive experience did not see a single case of resultant tuberculosis even in those cases where the projectile had damaged the apex. De La Villéon, however, saw a few cases of tuberculosis develop after infected wounds (e.g., prolonged suppuration from empyemata, etc.), and he ascribes the onset of tuberculosis to accruing debility.

The whole problem of the relationship between lung disease and trauma has been made a special study by Blum.

Organization of a lung hæmatoma or rupture is usually a rapid and complete process with scarcely any resulting change in the lung. Koenig has reported a case in which the edges of a tear in a lung forty hours after trauma were united so firmly that the lung could be blown up without air escaping, and similarly in Dieffenbach's case the margins of the laceration were bound together by fresh fibrin a few hours after injury.

Occasionally, marked fibrosis may produce changes in the affected lung and adjoining viscera. The heart and mediastinum may be drawn over to the affected side. In Kohler's case there was shrinkage of the lung apex simulating tuberculosis. A case of injury to the right lung with possible hæmothorax, observed twelve years after injury by Mollard, Rotger, and Quirno, showed a pseudo-cavitation syndrome of the right apex, deviation of the œsophagus, and total dextrocardia. Cucchini's remarkable case of post-traumatic calcification, seen ten years after a wound in the lung, must be unique.

TREATMENT

Many cases of lung injury are hopeless from the beginning. As to the rest, Sauerbruch generalizes: "no patient must be allowed to die from a progressive internal hæmorrhage, nor must the mechanical effect of a pneumothorax continue to threaten respiratory and cardiovascular function. Otherwise operation is rarely

necessary." Provided the clinical condition remains good the mere presence of a pneumothorax or hæmothorax, or both, is no immediate indication for operation. A hæmothorax, however, should be aspirated if unchanged after ten days. If infection supervenes drainage is needed. Mediastinal emphysema has been successfully treated by immediate suprasternal drainage in the cases of Krauss, Tiegel, and Limón and Pera.

SUMMARY

A case of lung injury in the intact thorax is described. The mechanism, morbid anatomy, and symptomatology of this type of lesion are reviewed. Attention is drawn to its probable frequency and the value of radiological examination even in cases of slight injury.

I am indebted to Dr. R. H. Micks, Dr. C. L. McDonogh, and Miss Ethna MacCarthy, for much assistance.

BIBLIOGRAPHY

ADAMS, B. H., and POLAK, L. B., *Med. Bull. U.S. Navy*, 1933, **31**, 18.
BENNINGHOFF, G. E., *Internat. Jour. Surg.*, 1914, **27**, 46.
BLUM, J., *Fortschr. d. Med.*, 1921, **39**, 705.
BOUTILLIER, W. G. L., *Ann. of Surg.*, 1902, **35**, 553.
BROCK, R. C., *Guy's Hosp. Rep.*, 1936, **86**, 213.
CLAISSE, quoted by SCHWARTZ and DREYFUS.
COCKLE, W. P., *Brit. Med. Jour.*, 1902, **1**, 1333.
LE CONTE, R. G., *Ann. of Surg.*, 1908, **68**, 383.
COOKE, W. E., *Brit. Med. Jour.*, 1934, **2**, 629.
COURTOIS, *Thèse de Paris*, 1873, quoted by SCHWARTZ and DREYFUS.
CUCCHINI, F., *Quaderni Radiol.*, 1932, **3**, 26.
CUNNINGHAM, C. W., *Lancet*, 1912, **2**, 1012.
CUNNINGHAM, G. J., *Ibid.*, 1938, **2**, 1413.
DAVIES, H. MORRISTON, *Surgery of the Lung and Pleura*, 1930.
DAVISON, C., *Internat. Clinics*, 1922, **2**, 16.
DEAL, D., *Indust. Med.*, 1935, **4**, 178.
DIEFFENBACH, R. H., *Surg. Clin. N. Amer.*, 1926, **6**, 1581.
DUVAL, P., *War Wounds of the Lung*, 1918.
FISCHER, E., *Lungenrupturen bei intaktem Thorax*, 1912. Zurich.
GIOVANNI, C., *Ann. Omoidei*, clxxi (abs. in *Med. Times and Gaz.*, 1861, **1**, 68).
GORDON, J., *Lancet*, 1936, **2**, 178.
GOSSELIN, *Mém. Soc. Chir. de Paris*, 1847, **1**, 201.
HEALD, C. B., *Injuries and Sport*, 1931.
HENRY, H., and ELLIOTT, T. R., *Jour. Roy. Army Med. Corps*, 1916, **27**, 525.
JOANNIDES, M., and TSOULOS, G. D., *Arch. of Surg.*, 1930, **21**, 333.
KERR, J., *Med. News. Phil.*, 1894, **64**, 214.
KLUBS, *Arch. f. exper. Pathol. u. Pharmakol.*, 1909–10, **62**, 39.
KOENIG, quoted by BLUM.
KOHLER, F., *Med. Klinik*, 1910, **6**, 340.
KRAUSS, H., *Deut. Zeits. f. Chir.*, 1933, **160**, 239.
DE LAMBALLE, J., *Traité de Plaies par Armes à Feu*, 1883.
LAURENT, E. A., *Lancet*, 1883, **2**, 225.
LILIENTHAL, H., *Thoracic Surgery*, 1925.
LIMÓN, F. V., and PERA, C., *Rev. méd. de Barcelona*, 1927, **8**, 578.
LOCKWOOD, A. L., *Surg. Gynecol. and Obst.*, 1933, **61**, 542.
MCDONNELL, R., *Dubl. Quart. Jour. Med. Sci.*, 1864, 38.
MACKENZIE, C., quoted by VILLEGAS and LOS ANGELOS.
MAFFRÉ, M., *Arch. Méd. et Pharm. mil.*, 1908, **52**, 420.
MARSH, F., *Med. Times and Gaz.*, 1862, **2**, 59.
MARTIN, quoted by DUVAL.
MERCADÉ, quoted by SCHWARTZ and DREYFUS.
MOLLARD, H., ROTGER, E., and QUIRNO, N., *Rev. Assoc. méd. argent.*, 1933, **47**, 2019.

MOORE, G., *Lancet*, 1842, **I**, 205.
MORGAGNI, J. B., *De Sedibus et Causis Morborum*, 1761. Venice.
NANKIVELL, *Med. Times and Gaz.*, 1871, **62**, 247.
OVERHOLT, R. H., personal communication.
PAYNE, E. M., *Brit. Med. Jour.*, 1909, **I**, 139.
PEYROT, M., quoted by SCHWARTZ and DREYFUS.
PRIBOIANU, D., and BLECHMANN, M., *Arch. méd.-chir. de l'App. resp.*, 1934, **9**, 503.
REES, W. A., *Brit. Med. Jour.*, 1924, **I**, 1002.
ROCHER, H. L., and DUPÉRIÉ, R., *Bull. et Mém. Soc. Méd. et Chir. de Bordeaux*, 1927, 333.
SANTÉ, L. R., *Principles of Roentgenological Interpretation*, 1937; *Jour. Amer. Med. Assoc.*, 1928, **91**, 1603.
SAUERBRUCH, F., and O'SHAUGHNESSY, L., *Thoracic Surgery*, 1937.
SEARLS, H. H., *Surg. Clin. N. Amer.*, 1926, 6.
DU SÉJOUR, D., *Thèse de Paris*, 1901.
SELLORS, T. HOLMES, *Surgery of the Thorax*, 1933.
SERGENT, E., *Monde méd.*, 1932, **316**, 859.
SCHIFF, quoted by PRIBOIANU and BLECHMANN.
SCHWARTZ, A., and DREYFUS, P., *Rev. de Chir.*, 1907, **35**, 764.
SCOTT, H. H., *Lancet*, 1918, **I**, 21.
SICARD and ANASTAZE, *Bull. méd. de l'Algérie*, 1906, 126.
SMITH, R. W., *Dubl. Jour. Med. Sci.*, 1840, **18**, 149.
SMITH, SYDNEY, *Taylor's Principles and Practice of Medical Jurisprudence*, 1934.
SOURDILLE, *Soc. Anat. de Paris*, 1895.
STRANSKY, E., *Monats. f. Kinderheilk.*, 1930, **46**, 109.
THOMAS, W. C., quoted by LILIENTHAL.
TIEGEL, M., *Arch. f. klin. Chir.*, 1913, **4**, 845.
TRAUBE and VULPAIN, quoted by PRIBOIANU and BLECHMANN.
TRIEPEL, H., *Einführung in die physikalische Anatomie*, 1902. Wiesbaden.
TUCKER, W. E., *Injuries and their Treatment*, 1935.
VAISS, A., *Thèse de Paris*, 1906.
VILLEGAS, A., and DE LOS ANGELES, S., *Jour. Philippine Islands Med. Assoc.*, 1926, **6**, 15.
DE LA VILLÉON, E. P., *Bull de l'Acad. de Méd.*, 1921, **86**, 447.
WATERS, E. E., *Ind. Med. Gaz.*, 1903, **38**, 256.
WERWATH, K., *Med. Klinik*, 1927, **23**, 447.
WHARRY, H. G., *Brit. Med. Jour.*, 1890, **I**, 1369.
WIDERØE, S., *Norsk Mag. f. Laege.*, 1913, **74**, 1193.

CAROTID LIGATION IN SACCULAR INTRACRANIAL ANEURYSMS *

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In his paper " On the Saccular Aneurysms of the Internal Carotid Artery in the Cavernous Sinus ", Jefferson (1938) wrote that " the ill repute of ligature of the carotid vessels has grown out of statistics compiled from cases of infection, of secondary hæmorrhage, of malignant disease of the neck, and so forth. We need new statistics on the subject." The present investigation owes its origin to that suggestion. It is based on 60 cases of carotid ligature performed for the cure of saccular intracranial aneurysms of spontaneous origin. Twenty-seven of the cases in the present series have previously appeared in the literature, the remaining 33 I owe to the courtesy of members of the Society of British Neurological Surgeons.

In compiling this material I have had two objects in view: to compare the results of carotid ligation for this relatively new indication—saccular intracranial aneurysms—with the statistics of older writers; and to discuss the pathology of the cerebral complications which have been thought to be so common. As will appear, neural dysfunction occurs only in some cases, and the paralyses vary from the affection of one finger to complete hemiplegia and may last for minutes only or remain permanent. These facts indicate that special circumstances must favour the onset of neural damage, condition its severity, and determine the ultimate result. The factors underlying such variables have not been clearly understood; the various theories that have been put forward in explanation are discussed in the present paper. A critical survey of the cases presented below leads to the conclusion that the results of carotid ligation, whether good or bad, are dependent, not only on local conditions, but also on the systemic blood-flow and blood-pressure which are known to be so vitally important in maintaining the efficiency of the cerebral circulation.

HISTORICAL

Scientific interest in the function of the carotid vessels was first aroused by the effects of strangulation. Since Galen's days numerous experimental occlusions of these arteries were carried out in animals, but traumatic hæmorrhage forced surgeons to perform carotid ligation before physiologists could give a unanimous opinion on the possible dangers of the procedure. The first descriptions of the operation in man by John Abernethy (1798), D. Fleming (1803), and Amos Twitchell (1804) make exciting reading, and their accurate clinical and pathological observations give to these reports an importance beyond their historical interest. The first premeditated ligature of a common carotid artery was performed by Sir Astley Cooper (1805) for an extracranial aneurysm of the internal carotid artery. Although this patient died, Cooper repeated the operation in 1808, this time

* Based upon a paper read before the Society of British Neurological Surgeons in Manchester.

successfully. The second operation was witnessed by Benjamin Travers, who one year later performed it in a patient with pulsating exophthalmos, a condition which Travers had recognized to be due to an intracranial arteriovenous aneurysm.

In the first half of the nineteenth century the operation became widely practised, and to the original indications—traumatic hæmorrhage and aneurysm—others were added. These concerned a number of ill-understood conditions which had in common only the fact that they appeared referable to the territory supplied by the carotid arteries. Trigeminal neuralgia, epilepsy, and the psychoses were so treated, and in these patients whose general health was unimpaired the procedure was hardly ever followed by signs of cerebral damage, though ligation did little to relieve the patient's complaint. Surgeons who performed the operation for such cases were naturally inclined to regard it as a perfectly safe and harmless procedure, while others who reserved carotid ligature for more legitimate indications were aghast at this optimism. Their own experience with patients with hæmorrhage, aneurysm, and tumours of the face and mouth had taught them to regard carotid ligation as a highly dangerous procedure, in their opinion justified only in states of emergency. In 1868 Pilz published a classical paper on ligature of the common carotid artery based on no fewer than 600 cases, with a total mortality of 43 per cent. The striking dependence of the results of the operation on the patient's general state of health clearly emerges from Pilz's material, but its significance appears to have escaped his attention. Pilz limited the applicability of carotid ligation to hæmorrhage and aneurysm alone, and these have remained the only recognized indications.

Only in recent years has the principle of proximal arterial ligation been applied to the group of saccular intracranial aneurysms. The few patients suffering from this type of lesion who found their way to the surgeon during the first three decades of the present century were almost invariably first diagnosed and explored as cases of intracranial tumour, and only occasionally was carotid ligation performed after the diagnosis had been established by craniotomy. Wilfred Trotter (1924) appears to have been the first to ligate a carotid artery for a non-fistulous intracranial aneurysm without having first exposed the lesion. In this case the aneurysm was of traumatic origin and the indication severe epistaxis. F. J. Nattras's (1928) patient was correctly diagnosed as suffering from a spontaneous intracranial aneurysm on neurological grounds alone, and Professor Grey Turner ligated the internal carotid in this patient. The introduction of cerebral angiography by E. Moniz (1927) and its application to the diagnosis of intracranial aneurysms constituted an inestimable advance in the diagnosis of the lesions. At the same time the final diagnostic procedure was placed in the hands of the surgeon, for the carotid arteries may be ligated at the same operation should an aneurysm be found to be present. The collection by neurological surgeons of an increasing number of such cases has been the natural outcome of this evolution.

The treatment of these aneurysms by ligation of a carotid artery in the neck has so far received less attention than the problem of diagnosis.* Apart from 7 ligations by N. M. Dott (1933, 1937), 5 cases have been reported by N. M. Walsh and J. G. Love (1937, 1939) and 4 by G. Jefferson (1937, 1938). In

* See, however, the discussions by Dott and by Jefferson in the papers referred to; also Matas (1938), Dandy (1939).

addition to these I have found 11 cases reported by nine authors. The present statistics on 60 cases constitutes the largest collection which has so far appeared.

ANALYSIS OF THE MATERIAL

Synopsis of Cases.—Thirty-three of the sixty cases on which the present communication is based have not previously appeared in the literature. They were communicated to me by :—

Professor H. W. B. Cairns	2 cases
Mr. N. M. Dott	5 cases
Dr. D. Denny Brown	1 case
Professor G. Jefferson	10 cases
Mr. G. C. Knight	11 cases
Dr. I. Oljenick	2 cases
Mr. C. P. G. Wakeley	2 cases

The following 27 cases were collected from the literature :—

F. Albright (1929)	1 case
C. F. Beadles (1907)	1 case
N. M. Dott (1933)	1 case
K. Hermann, S. Obrador, and N. M. Dott (1937)	6 cases
D. Furtado (1938)	1 case
R. T. Hill (1938)	2 cases
G. Jefferson (1937)	1 case
G. Jefferson (1938)	3 cases
V. Magnus (1927)	1 case
C. A. McKindree and L. J. Doshay (1936)	1 case
F. J. Nattras (1928)	1 case
A. C. De Vet and A. Zeckel (1937)	1 case
Cl. Vincent, F. Thiebaut, J. Lemoyne, and L. Guillaumat (1937)	2 cases
M. N. Walsh and J. G. Love (1937)	1 case
M. N. Walsh and J. G. Love (1937)	4 cases

In the present series of 60 cases of carotid ligation the operation was performed on 22 patients suffering from an infraclinoid aneurysm, and on 29 patients with a supraclinoid aneurysm at the circle of Willis. Three aneurysms were situated on the posterior communicating artery, 1 was connected with the middle cerebral artery, and 1 arose from the junction of the anterior communicating with the anterior cerebral artery. In another 4 cases the exact situation of the aneurysm was not ascertained. In all, 8 of the 60 patients died (13·3 per cent), but only 3 were hemiplegic before death. Of the patients who survived, 8 showed evidence of cerebral damage in the form of contralateral neurological dysfunction after ligature of one carotid artery. The distribution of these 16 cases in which ligature was followed by death or neurological complications is shown in *Table I.*

It appears justifiable to conclude that the outcome of the operation is determined by the anatomy of the lesion. Before arriving at a more definite conclusion about this relationship it will be necessary to investigate some of the pertinent clinical features presented by the patients before operation. Should this analysis reveal a factor present in all cases in which ligation ended fatally or was followed by severe cerebral damage, and absent in those surviving without neurological complications, it would be reasonable to conclude that this factor must have been the cause of the cerebral damage or death. This common denominator I believe

Table I.—Showing Site of Aneurysm in Cases followed by Death or Neurological Complications

Site of Aneurysm	No. of Patients	Died	Neurological Complications
Infraclinoid	22	0	3 (13·3 per cent)
Supraclinoid	29	5 (17·2 per cent), 2 preceded by hemiplegia	4 (13·7 per cent)
On branches of internal carotid	5	3 (60 per cent), 1 preceded by hemiplegia	1 (20 per cent)
Unverified	4	0	0
Total	60	8 (13·3 per cent)	8 (13·3 per cent)

to be *pre-operative impairment of the cerebral circulation.* Aneurysms may interfere with the cerebral circulation in more than one way. They may raise the intracranial tension by leakage or rupture into the subarachnoid space, or they may, by their size and situation, compress a main cerebral artery at the base of the brain. If these effects are severe enough, spontaneous neurological dysfunction will show itself clinically. Lesser degrees of interference with the cerebral circulation, however, may only become apparent after further reduction of the cerebral blood-flow, i.e., after carotid ligation.

INFRACLINOID ANEURYSMS

(22 cases, no deaths)

It has already been stated that all the patients in whom ligature was performed for an infraclinoid aneurysm survived. Only 3 of the 22 patients developed post-operative neurological signs.

The aneurysms in the cavernous sinus are fortunately placed, for the dural envelope surrounding them on all sides prevents their spontaneous rupture and to a certain extent limits their expansion. Should the aneurysm burst spontaneously before its walls have made contact with the walls of the cavernous sinus, an arteriovenous fistula results. Infraclinoid aneurysms do not give rise to subarachnoid hæmorrhage, and their effects, disabling and painful though they are, remain limited to compression of neighbouring nerves. They do not, if untreated, constitute an immediate danger to the life of the patient. Ligation of the carotid vessels in these cases is resorted to in order to save the patient's sight and to relieve pain in the distribution of the trigeminal nerve (for a full description of these aneurysms *see* Jefferson, 1938).

In 2 patients with infraclinoid aneurysm the disturbances following ligature of the internal carotid were severe. In both instances the ligature was performed to control life-threatening hæmorrhage from a lacerated aneurysm.

Case 1 (Jefferson).—Male, aged 34. Following the removal of nasal polypi, severe epistaxis occurred and could not be controlled by nasal plugs, the hæmorrhage being so forceful that the packing was pushed out. Every time the dressing was changed a life-threatening hæmorrhage occurred. When first seen by Jefferson the patient was badly exsanguinated, although two blood transfusions had been given. It was assumed that an infraclinoid aneurysm had eroded into the sphenoidal sinus. Ligature of the left internal

carotid artery in the neck was performed after digital compression for half an hour had led to no untoward sign. Thirty-six hours after ligation a right-sided hemiparesis and an aphasia appeared. The patient was given a further blood transfusion in the belief that the paralysis might be caused by an inefficient cerebral circulation due to the lowered blood-volume. As his general state improved, the hemiparesis and aphasia cleared up. He was discharged three weeks after the ligature, and at that time he was still slightly aphasic, but the hemiplegia had completely disappeared. He was seen again six months later, his only complaints at that time being lack of concentration and occasional difficulty in remembering words. One and a half years after operation he had quite recovered, but he had recently had two attacks of syncope.

Comment.—When first seen this patient was suffering from acute anæmia due to severe blood-loss. Ligature of the internal carotid was carried out as an emergency measure to control the hæmorrhage, and not to treat the aneurysm. Comparison of the events in this case with the tranquil post-operative course in ligations for uncomplicated infraclinoid aneurysms makes it reasonable to conclude that the neurological disturbances must have been more closely related to exsanguination than to the ligation of the internal carotid or to the presence of the aneurysm. The loss of blood and consequent reduction in blood-volume and pressure constituted a severe handicap to the efficiency of the cerebral circulation, but as long as the main arteries remained patent the blood-supply to the brain continued to be efficient. The blood transfusions given to improve the cerebral circulation no doubt contributed greatly to the patient's recovery. The attacks of syncope of which he has recently complained may either be evidence of an ischæmic cerebral scar acting as an epileptogenic focus, or they may occur when for systemic reasons his blood-pressure falls below the level at which the intracranial collateral vessels can keep up an efficient blood-supply to the hemisphere bereaved of its main artery.

Damage to an infraclinoid aneurysm during or after a nasal operation is very rare. Apart from the above case reported by Jefferson (1938) I could find only one other (A. Reinhardt, 1913). Here the aneurysm, after erosion of the sphenoidal sinus, presented itself as an intranasal tumour and was incised with fatal result. O. Sjøqvist (1936) reported a case in which angiography was performed after lipiodol had been introduced into the sphenoidal sinus. Only a thin layer of bone was seen to intervene between the aneurysm and the sinus.

Severe epistaxis due to the rupture of a traumatic intracavernous aneurysm has been described by C. A. Griffiths (1915), J. L. Birley (1928), and E. D. D. Davies (1939). These cases have not been included in the present series of spontaneous aneurysms.

Case 2 (Magnus).—Male, aged 69. During an exploration of the middle cranial fossa an infraclinoid aneurysm of the internal carotid was exposed. It had been proposed to cut the trigeminal root for what was thought clinically to be tic douloureux. The aneurysm was incised, and the ensuing hæmorrhage made ligature of the internal carotid artery in the neck imperative. The patient survived, but a permanent slight paralysis of the contralateral arm appeared immediately after operation. Apart from this he made an uneventful recovery.

Comment.—Ligature was again undertaken in the presence of hæmorrhage which could not be controlled locally. The paralysis, although slight from the outset, proved to be permanent.

The third patient in this group to show neurological dysfunction was :—

Case 3 (Jefferson).—Female, aged 58. Clinically she presented a syndrome typical of an aneurysm in the posterior part of the cavernous sinus. Thorotrast injection showed an unusually large aneurysm involving the entire intracavernous course of the internal carotid artery. The cerebral vessels were only poorly filled. Four days after the right internal carotid artery had been ligated in the neck she volunteered the information that her left thumb felt stiff. Movements of the thumb were weak and always accompanied by involuntary movements of the right thumb. No other neurological sign was present, and she was discharged in excellent health. Ten months later the left thumb was still clumsy.

Comment.—*Fig.* 34 shows the dimensions of the aneurysm, the largest that we had seen by angiography. The nature of the cerebral lesion can only be guessed at. It is possible that the large tumour compressed basal vessels and interfered with the establishment of an efficient collateral circulation.

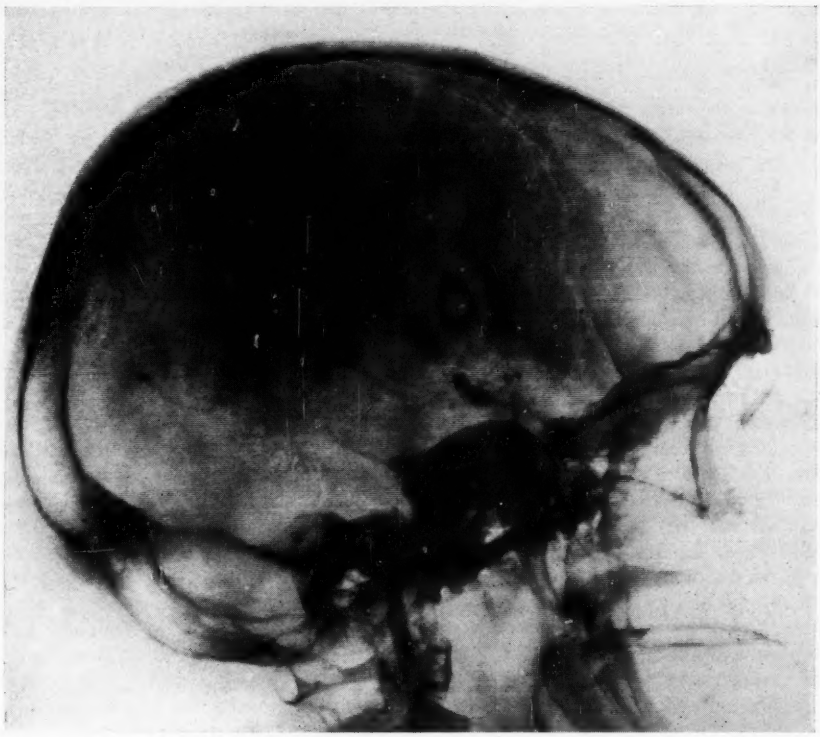

FIG. 34.—Angiogram from *Case* 3. Note the poor filling of the cerebral vessels. A large infraclinoid aneurysm is outlined.

In the remaining 19 patients with infraclinoid aneurysms ligation was well tolerated. The aneurysms had been uncomplicated before operation and no sign suggestive of cerebral damage followed the application of the ligature.

SUPRACLINOID ANEURYSMS

Thirty-four patients belong to this group. It includes aneurysms situated on a branch of the internal carotid in addition to those having their origin from the intradural portion of the main vessel. On clinical grounds this group may be subdivided into: (1) Uncomplicated aneurysms; and (2) Aneurysms which had leaked into the subarachnoid space. It will be seen how different are the results in the two categories.

1. SUPRACLINOID ANEURYSMS WITHOUT LEAKAGE
(22 cases, 3 deaths)

The aneurysms in this group betrayed their presence by neighbourhood signs, particularly ocular nerve palsies, and by signs of increased intracranial tension. They resemble in this respect the infraclinoid aneurysms. Their growth may take place by simple enlargement of the sac itself, a repetition of the mechanism which

in the first place led to the formation of the aneurysm, or repeated leakages of blood into the immediate neighbourhood may produce layers of clot around the original lesion. Frequently these two mechanisms are present in combination.*

In addition to the compression of neighbouring nervous structures and the rise in intracranial tension a third effect may be produced by supraclinoid aneurysms through pressure on blood-vessels in their vicinity. In this manner they may affect their own parent trunk or other arteries at the circle of Willis. This arterial obstruction, remaining incomplete under ordinary conditions, may become clinically manifest in the form of grave neurological dysfunction after occlusion of the main artery to the hemisphere. The importance of this factor emerges clearly from two fatal cases in the group under discussion.

Case 4 (Albright).—Male, aged 33. Six weeks before admission to hospital a subarachnoid hæmorrhage had occurred in this patient. An aneurysm of the internal carotid artery at the circle of Willis was diagnosed. It was decided to ligate the internal carotid artery in the neck with a view to improving the intracranial collateral circulation. Twenty-four hours later, however, a second subarachnoid hæmorrhage occurred and immediate ligature was indicated. Dr. W. E. Dandy partially occluded the internal carotid in the neck with an aluminium band. The precaution of not entirely occluding the lumen of the vessel was taken because digital compression had caused dizziness and faintness. Soon after the operation the patient became increasingly drowsy, later disorientated, and seven hours after the ligation weakness of the limbs on the side opposite to the ligated artery was first noted. Two hours later he became unconscious. The wound in the neck was re-opened and the band loosened. On the third post-operative day his condition deteriorated still further, and the band was removed. At this operation the artery was seen to pulsate throughout its exposed length. Two hours later the patient died.

At Autopsy.—Ruptured aneurysm of the left posterior communicating artery forming a false aneurysmal sac. This compressed the middle cerebral artery on the same side. The whole area of supply of the left middle cerebral artery was necrotic. A small unruptured aneurysm was situated on the right posterior communicating artery. No thrombus was seen at the site of ligation, and the internal carotid artery and its branches were patent.

Comment.—The cause of death is clearly to be seen in the combination of two factors: local compression of the middle cerebral artery by the sac of the false aneurysm; and reduction of the blood-volume consequent upon carotid ligation. The pre-operative flow of blood through the middle cerebral must have been severely impeded because even partial ligation of the internal carotid caused irretrievable damage.

Case 5 (Denny Brown).—Male, aged 51. Admitted to the National Hospital, Queen Square, under the care of Dr. Denny Brown, who kindly gave me permission to include this case in the present series. The patient complained of having suffered from headaches and pain in the legs for the past four years. During the month before his admission his eyesight had deteriorated. Examination revealed bilateral optic atrophy, more marked on the right, and an incongruous hemianopia to the left.

Angiography: Large aneurysm of the right internal carotid anterior to the sella. It was thought inadvisable to ligate the internal carotid soon after the injection of thorotrast, and the patient was discharged. Five months later he was re-admitted. He had become drowsy and irritable in the interval, but his clinical state had not changed otherwise. The right internal carotid artery was ligated in the neck.

Twenty-four hours after operation: Slight weakness of right limbs was first noticed.

Second post-operative day: He was drowsy and unco-operative. The abdominal reflexes were absent and the plantar response on the left was extensor. Paralysis of the left limbs was moderate and sensation was disturbed on that side.

Fourth day: Weakness of left lower face, left arm flaccid and could not be moved actively. Weakness of the left leg increased, but he could move the ankle.

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* Although this localized bleeding is subarachnoid in a stricter sense, the term 'subarachnoid hæmorrhage' has been reserved for the generalized effusions.

Fifth day: Complete left hemiplegia.
Eighth day: Disorientated and delirious. Moved the left foot slightly at the ankle.
Thirteenth day: Died.

POST-MORTEM EXAMINATION (*Dr. J. G. Greenfield*).—A rounded aneurysmal mass was seen to fill the right side of the retrochiasmal region, stretching the optic chiasma in front of it. The sella was flattened on its right side and the right anterior clinoid process eroded. The pituitary was small and pushed to the left. The internal carotid artery, which was not thrombosed, lay in its sigmoid course on the outer wall of the aneurysm, and opened on its inner surface into the cavity of the aneurysm. The aneurysm did not, however, interrupt the course of the internal carotid which was continued along its outer wall into the middle and anterior cerebral and posterior communicating arteries. All the branches were free from clot. The right anterior cerebral supplied only the anterior part of the internal surface of the hemisphere. There was a single callosal branch arising from the upper aspect of the anterior communicating, which turned to the right at the middle of the corpus callosum to supply the callosomarginal and precentral gyri. All the arteries of the circle were thin and free from atheroma.

On section of the brain, the cortex of the central and precentral gyri of the right side towards the vertex looked yellowish and the white matter under them congested and softer than normal down to the upper wall of the ventricle. The right oculomotor nerve was attached to the outer wall of the aneurysm by rather dense fibrous tissue arising from the dura mater.

Comment.—The slow onset of the hemiplegia which was not complete until the fifth post-operative day and the gradual deterioration in the patient's general state leading to death on the thirteenth day are remarkable in this case. The pathological findings were essentially the same as in *Case* 4 (Albright), namely, local obstruction to the cerebral circulation by compression of the middle cerebral artery by the aneurysm. The histological characteristics of the lesion will be described later; its extent coincided with the territory supplied by the middle cerebral artery.

Two patients in this group developed slight transitory signs of cerebral damage after operation, but recovered. In one of these thorotrast failed to enter the anterior cerebral artery and it was assumed that the aneurysm, situated near the origin of this vessel, had compressed it. Digital compression of the internal carotid had been well tolerated for fifty minutes; in spite of this, transitory hemiplegia developed fifty hours after the internal carotid had been tied.

These three cases exemplify the fact that a cerebral vessel may be compressed by an aneurysm without clinical signs becoming apparent until the flow of blood is still further reduced. This reduction may occur after carotid ligation, but a similar mechanism may be at work when a spontaneous hemiplegia appears in a patient suffering from a basal aneurysm. In these spontaneous cases the further impediment to the cerebral blood-flow may be occasioned by an increase in the size of the aneurysm or by an increase in intracranial tension as occurs in subarachnoid hæmorrhage.*

Transient signs appeared after ligation in one case and may well have been due to similar conditions, though no proof can be given for this assumption.

One more case in this group needs special comment:—

Case 6 (Knight).—Female, aged 58. Angiography confirmed the clinical diagnosis of supraclinoid aneurysm. The internal carotid artery was ligated in the neck. After operation the patient became increasingly drowsy and died forty-eight later with signs of cardiac decompensation. No paralysis was noted clinically and necropsy failed to reveal any cerebral pathology.

* Jefferson (1938) commented on the view, held by many, that the very fact of the presence of an aneurysm can be counted upon to improve the collateral circulation. He suggested that the peculiarities of the arrangement of the cerebral vessels might have the contrary effect, and these cases support this view.

Comment.—In the absence of clinical signs and without the evidence of a histological examination of the brain it is difficult to explain this patient's death satisfactorily. It is possible that unilateral cerebral damage was produced by a combination of cardiac decompensation and the occlusion of one carotid artery, but that severe terminal anoxæmia so depressed the central excitatory state both in brain and spinal cord that the expected localizing signs did not materialize.

In this group of supraclinoid aneurysms the mortality was 13·6 per cent and the incidence of non-fatal hemiparesis 9·0 per cent. I have offered local compression of a basal artery as one explanation of cerebral damage following ligation in this group. The depression of the cerebral circulation associated with a rise of intracranial tension in the presence of an aneurysm is another important factor.

2. Supraclinoid Aneurysms with Leakage
(12 cases, 5 deaths after carotid ligature)

Subarachnoid hæmorrhage, often severe, had occurred in 12 patients. In 9 patients the aneurysm had bled a short time before ligature was undertaken, and of these cases 5 died. Of the 4 survivors 3 had transient signs of neural damage, and 1 patient recovered only after a long and severe illness. In 3 patients with old-standing subarachnoid hæmorrhage no ill effects followed carotid occlusion. These figures need little comment; they show in an impressive manner the dangers of ligating a carotid artery in the presence of recent subarachnoid hæmorrhage.

The clinical features presented by the cases with recent subarachnoid hæmorrhage need not be recounted in detail. One of them may serve as an example:—

Case 7 (Jefferson).—A female, aged 45, had been diagnosed as suffering from a supraclinoid aneurysm of the left internal carotid artery some months before she was seen at another hospital. She had been comatose for two days, her cerebrospinal fluid contained blood, and there could be no doubt that the aneurysm had burst.

Ligature of the internal carotid artery and a subtemporal decompression on the left side were performed. About twelve hours later the patient died without having regained consciousness and without having shown any additional neurological signs. Necropsy revealed a small flask-shaped aneurysm of the internal carotid artery at its junction with the posterior communicating. The aneurysm had ruptured, flooding the subarachnoid space. Clot entirely filled the left lateral ventricle.

Comment.—The severe subarachnoid and intraventricular hæmorrhage must have been present before operation. It might be thought that decompression, by lowering the intracranial tension, would allow more blood to escape from the ruptured vessel, but ligature of the internal carotid should counteract this possible effect. This patient would certainly have died had no operation been undertaken, and the ligature of the internal carotid can have contributed only slightly to the fatal outcome.

Very similar conditions were present in the remaining 4 fatalities in this group. A case of Jefferson's, a female aged 59, had been comatose for three days before the internal carotid was ligated. She died six hours after operation; extensive subarachnoid hæmorrhage originating from an aneurysm of the posterior communicating artery was found post mortem. Two of Dott's cases died 16 and 18 hours respectively after internal carotid ligation; both had had recurrent subarachnoid hæmorrhages. A necropsy was performed on one of these and "showed the internal carotid thrombosed from the site of ligature to a point just short of bifurcation. Anterior and middle cerebral arteries patent". Although no recent subarachnoid hæmorrhage was demonstrated post mortem, the case has been included in this group, for the cerebrospinal fluid was blood-stained before operation

and a slight leakage of blood from the aneurysm must have been present at that time. Generalized convulsions occurred in this case, and although no hemiplegia followed the operation, the hemisphere on the side of ligation was found to be œdematous and engorged. In another case of Dott's, thorotrast had failed to outline the anterior and middle cerebral arteries, evidence of compression of these vessels by the aneurysm. She died three hours after carotid ligation, and necropsy showed extensive subarachnoid and intracerebral hæmorrhage from a ruptured aneurysm of the middle cerebral artery. It is clear, therefore, that emergency ligation in these circumstances is dangerous.

In 3 patients with recent leakage from a supraclinoid aneurysm ligature of the internal carotid was followed by slight contralateral neural dysfunction. One of them complained only of tingling in the fingers of the contralateral hand for about five minutes after the vessel had been occluded. Another patient was aphasic for some minutes on the third post-operative day. In the third case an incomplete hemiparesis appeared twenty-four hours after the ligation and resolved in the course of a week. Only a slight facial weakness remained. These patients were fully conscious before operation and remained so throughout, and one may assume that the leakage of blood into the subarachnoid space and the subsequent increase of intracranial tension cannot have been excessive.

In the introduction to this analysis of the material the view was expressed that pre-operative impairment of the cerebral circulation accounts for the onset of cerebral damage after carotid ligation in patients with aneurysm. This view has been exemplified by the foregoing analysis. The infraclinoid aneurysms were remarkably free from post-operative complication, and unusual conditions were present in the three cases in which neural damage occurred. In the supraclinoid aneurysms the highest percentage of neurological complications and the highest mortality were found in the group with recent aneurysmal leakage. Subarachnoid hæmorrhage raises the intracranial tension by its bulk, by the obstruction of cerebrospinal fluid pathways, and, most important of all, by osmotic attraction of fluid. An increase in intracranial tension is not the only factor which may impede the cerebral blood-flow. Compression of basal vessels is equally important, and the combination of these two conditions may lead to critical embarrassment of the cerebral circulation even without the obstruction of the main artery to the hemisphere. This mechanism, in the writer's opinion, accounts for a large number of spontaneous hemiplegias occurring in patients who have supraclinoid aneurysms.

The practical implications of these considerations are obvious and need only be shortly enumerated. In infraclinoid aneurysms carotid ligation is a safe procedure. In supraclinoid aneurysms it is highly dangerous, and in the presence of extensive subarachnoid hæmorrhage it is almost certain either to be fatal or to be followed by neural damage of varying intensity. The direct attack on supraclinoid aneurysms appears to hold out more hope of success.*

* N. M. Dott (1933, 1937), G. Jefferson (1937, 1938), and A. A. McConnell (1937) have had successes with the placing of muscle grafts directly on the aneurysm. W. E. Dandy (1938, 1939) has reported three cases cured by the direct application of silver clips. In Dandy's last paper a full discussion of the treatment of non-fistulous intracranial aneurysms is to be found.

THE PATHOLOGY OF THE CEREBRAL LESION*

In the extensive literature on carotid ligation I have been able to find only 3 detailed descriptions of the histological changes which may follow this operation (G. Müller, 1930; G. Döring, 1936). To these I have 1 case to add (*Case* 5, Denny Brown); its histological characteristics may be summarized :—

1. In serial sections of the right middle cerebral artery and its branches no ante-mortem clot was found. It may be recalled that naked-eye examination of the specimen had shown no thrombus or embolus. Particular attention was paid to the middle cerebral artery because the pathological changes in the brain were chiefly in the territory supplied by this vessel.

2. Patchy necrosis affected a territory which on the surface included the central and precentral regions, and in the interior of the hemisphere involved the white matter under the affected cortex, the putamen, a narrow strip in the outermost portion of the globus pallidus, and the most anterior portion of the internal capsule.

3. In the affected areas all neural elements had disappeared. Their place was taken by proliferating blood-vessels and cells, chiefly of mesodermal origin, though some progressive astrocytes were also seen. Many cells were loaded with iron pigments or contained fat. The intimal lining of the majority of vessels in the necrotic territories was greatly thickened by proliferation of endothelial cells, and in many vessels the lumen had been obliterated by this process (*Figs.* 35, 36).

4. The remainder of the right hemisphere and the left hemisphere were normal.

5. No thorotrast was seen, although particular attention was paid to this point.

The right hemisphere, and more particularly the territory supplied by the middle cerebral artery, was found to be affected by a patchy necrosis similar to the colliquation necrosis described by W. Spielmeyer (1922). Marked endothelial thickening of the vessels in the necrotic areas was an additional finding in the present case and deserves special comment. This feature is usually associated with chronic lesions. Now, the clinical data of the present case, e.g., the patient's increasing drowsiness prior to the performance of carotid ligation, suggest that some cerebral impairment was present even before the operation, and it is possible that the compression of the middle cerebral artery by the aneurysm prior to ligation produced in some areas a degree of anoxæmia sufficient to induce proliferation of the vascular endothelium. In this manner, it may be supposed a local resistance to the blood-flow was produced, thus predisposing some areas to severe anoxæmic damage after carotid occlusion.

The histological features of the present case differ markedly from the three cases described in the literature. In these almost the entire hemisphere on the side of ligation was affected by diffuse anoxæmic damage; in Döring's case even the opposite hemisphere showed similar, but less severe, changes. Although affecting a very much larger area, the degree of anoxæmic damage was not as severe as in the present case, and no proliferating elements were seen. In Müller's and Döring's cases the carotid arteries were ligated in the course of removal of growths involving the vessels. The patients had been in poor health, and the operative loss of blood must have impaired their systemic circulation. The functional inefficiency of the collateral supply through the circle of Willis must

* This investigation was carried out in the Department of Pathology, National Hospital, Queen Square. I am greatly indebted to Dr. J. G. Greenfield for his kind help and advice.

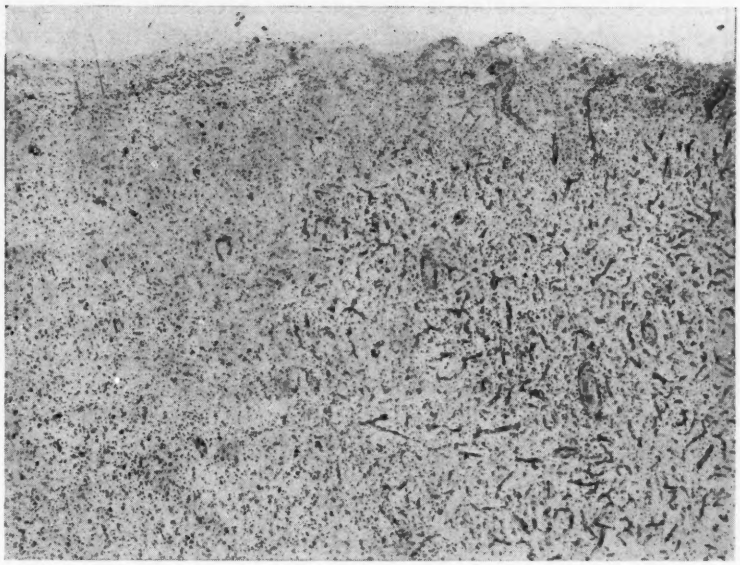


FIG. 35.—Photomicrograph showing a necrotic area to the right and normal cortex to the left. The border-line between the two areas is well marked. Abundant blood-vessels are the main feature in the necrotic territory.

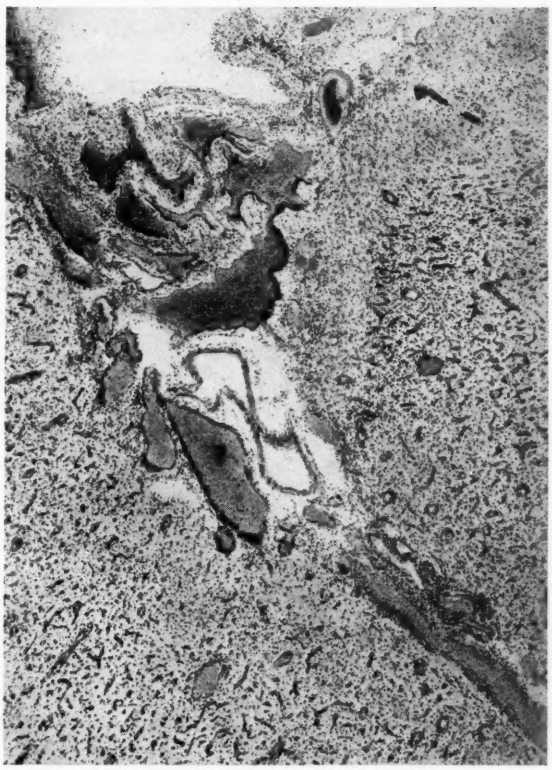


FIG. 36.—Necrotic area. Proliferated vessels, many of them showing intimal hyperplasia.

have been part of the depression of the systemic circulation. In *Case* 5 (Denny Brown) of the present series local vascular compression by the aneurysm was the cause of circulatory failure, and consequently severe damage was seen in areas supplied by the middle cerebral artery. The remainder of the hemisphere was not affected, for the powers of the systemic circulation were not impaired by the lesion.

Neither in the present case nor in the three cases reported in the literature was a thrombus or embolus seen.

Cerebral anoxæmia may produce a variety of histological pictures. Its extent and severity after carotid ligation depend largely on the pre-operative state of the patient's systemic circulation, and the effect produced by intracranial lesions on the cerebral circulation. The manifold clinical pictures encountered after carotid ligation may be correlated with a variety of pathological states. The histology of these lesions needs fuller investigation.

THEORIES OF POST-OPERATIVE NEURAL DAMAGE

Only the more important theories that have been put forward to explain the occurrence of cerebral damage after carotid ligation will be discussed.

a. **The Embolic Theory.**—First formulated by L. Le Fort (1868), and more recently advocated by Perthes (1920), this theory is subscribed to by many. It assumes the formation of a thrombus at the site of ligation and the subsequent occlusion of a larger cerebral artery by an embolus or by extension of the thrombus. This would explain the delayed onset of neurological complications and the suddenness with which they are said to make their appearance. Perthes believed ligature of the common carotid to be more dangerous than ligature of the internal carotid, for after common carotid ligation the reversed blood-flow in the external carotid would, in Perthes's opinion, tend to sweep clots into the cerebral arteries. This conclusion is so reasonable that one might test the truth of the embolic theory by comparing the results of common and internal carotid ligation. In the present series no death followed 11 ligatures of the common carotid, and no neurological complications were observed in these patients. On the other hand, the mortality was 16·3 per cent and the incidence of paralyses 22·4 per cent in 49 ligatures of the internal carotid artery. A survey of the figures given by other authors confirms the impression conveyed by my material, and there can be no doubt that internal carotid occlusion is the more dangerous procedure in a comparable series of cases. This fact destroys a mainstay of the embolic theory. Common carotid ligature has been usually preferred for poor risks, so that deaths and paralyses should be common for that reason alone. This fact must be given due weight in assessing the examples recorded in the literature. It is the thesis of this paper that such factors as severe illness play an important and often a dominant part in the consequent disaster.

The pathological evidence in the literature does not support the embolic theory, since the number of clots found at necropsy after carotid ligation has been very small. A thrombus is likely to form only if the vessel wall is infected, bruised, or sclerotic, for these conditions combine with the stagnation of blood consequent upon ligature to produce a clot.* Even in these cases only rarely can the anatomy

* In animal experiments sepsis is the main factor favouring clot formation (A. McLean, 1915; R. H. Miller and H. Rogers, 1929; J. Homans, 1929).

of the thrombus explain the failure of the cerebral blood-supply. It is reasonable to regard the clot as a consequence of blood stagnation and not as its cause. In the present series a clot was seen once at post-mortem examination (Dott). It extended from the site of ligation to the bifurcation of the internal carotid, but it must be observed that the vessels at and beyond the circle of Willis had remained patent.

In most cases an interval elapses between the application of the ligature and the onset of signs of cerebral damage. The significance of the delayed onset of neural damage may be suitably discussed in connexion with the embolic theory, for most authors have followed Perthes in believing the interval to be due to the time taken by the formation of a thrombus and the loosening of an embolus. A period varying from minutes to days and weeks may elapse; in the present series five minutes was the shortest and four days the longest interval. Only in one patient did neurological signs appear as soon as the ligature had been tied.* Le Fort (1868), commenting on the delayed onset of neural damage, found the second post-operative day to be the most critical period. Ten of a total of 45 hemiplegias in his series occurred at that time. No relationship exists between the severity or the subsequent duration of the paralysis and its time of onset. Occasionally a paralysis may resolve, and be followed by another weeks or months later. A. Cauchoix (1922) tells the story of a patient in whom ligature of the right common carotid was followed by a transient left-sided facial weakness; three months later a complete hemiplegia of the left side appeared.

Theoretically, a degree of cerebral anoxæmia must always follow the occlusion of a carotid artery, but it need not become severe enough to betray its presence in a clinically tangible manner. The actual occurrence of neural dysfunction depends on the severity of the anoxæmia and on the extent of the area affected; the initiation of the pathological process and its clinical manifestation need not coincide in time. Our methods of neurological examination at the bedside enable us to detect a late stage in the evolution of cerebral anoxæmia; an instrument more delicate than the tendon hammer might register its onset. The variability of clinical signs and the delayed appearance of neurological disabilities can be correlated with the conception of an anoxæmic process, influenced in its progress by the general health of the patient, particularly his blood-pressure and blood-volume. An explanation in static terms of cerebral softenings and irrevocable damage from embolic occlusion is inadequate. Irreparable cerebral damage may follow carotid ligation as the final stage of a severe impairment of the cerebral circulation (*Cases* 4, 5); the transient paralyses in patients who survive must be due to temporary functional impairment of neural elements by a degree of carbon-dioxide tension insufficient to cause permanent anatomical damage. In many respects this process appears comparable with various forms of anæsthesia, particularly nitrous oxide. Two examples from the literature serve to illustrate this conception: the first patient in whom Sir Astley Cooper performed carotid ligation became hemiplegic on the eighth post-operative day, and died three weeks after the operation. Cooper noted that the intensity of the hemiplegia varied with the general state of the patient's health, and he wrote about the paralysis: "It came on while she laboured under great constitutional irritation, lessened as it decreased,

* Jefferson (1938) described this happening in a patient with a fistulous aneurysm where the tentatively applied ligature had to be immediately removed.

and returned when the irritation became greater". If one translates Sir Astley Cooper's "constitutional irritation" into modern conceptions of blood-pressure and blood-flow, his observations appear as the true answer to the problem. The second example is a case described by A. Siegrist (1900). Twenty-four hours after the left internal and external carotid arteries had been ligated his patient complained of transient visual disturbances. Twelve days later the patient got up from his bed for the first time, and after walking a few steps he fell to the ground. He was examined almost at once and found to be conscious, but aphasic and paralysed on the right side. He was returned to bed and recovered completely in a few hours. It is reasonable to assume that temporary cerebral anæmia, the 'dizziness' experienced by everybody on assuming an erect attitude after a prolonged stay in bed, expressed itself in this patient in a hemiplegia.

It is possible that the cerebral circulation on the side of the ligated artery may remain in some patients a place of lessened resistance, but the information in the literature concerning the late results of carotid ligation is so scanty that the problem cannot be discussed. This thought comes to mind because Cooper's second case of carotid ligation died after thirteen years from a cerebral hæmorrhage on the side on which the carotid had been ligated.

b. **Anatomical Inefficiency of the Circle of Willis.**—Anatomical variations in the size and arrangement of the circle arteries are frequently seen, but their

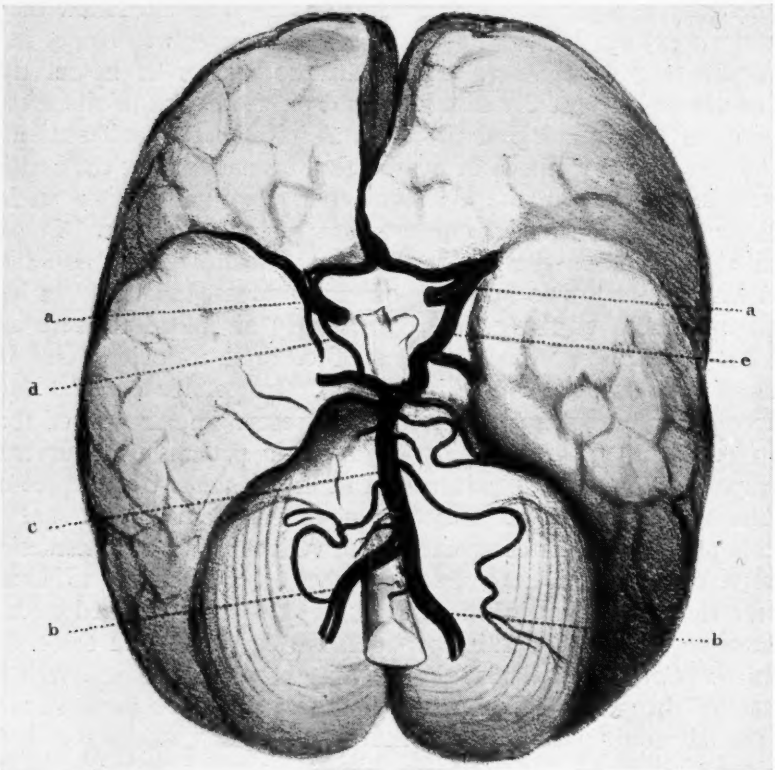


FIG. 37.—Basal view of the specimen from Cooper's first successful case of carotid ligation. *aa*, Internal carotid artery; *bb*, Vertebral artery; *c*, Basilar artery; *d*, Right posterior communicating artery; *e*, Enlarged left posterior communicating artery. (*Reproduced by kind permission from Guy's Hospital Reports*, 1836)

size according to E. Moniz (1938) is the expression of functional variability and must not be regarded as rigid anatomical deviations from the normal average. The adaptation of the circle arteries to functional demands is illustrated by Cooper's case (*Fig.* 37). The anterior communicating artery is hardly ever absent; its many variations (e.g., duplication) tend to make collateral circulation more efficient. B. Adachi (1928), in a review of the literature, found reports on the examination of 1653 circles of Willis, representing the data collected by nine authors; only 4 times was the anterior communicating artery entirely absent.

F. Brüning (1926) believed that carotid ligation may be followed by two types of cerebral lesion: irreparable anæmic; and congestive with a tendency to recover. Cerebral anæmia in his opinion could be caused by primary inefficiency of the circle of Willis or by a clot obstructing an artery. The foregoing discussion has shown that these theoretical assumptions are not supported by anatomical facts, and the view has been expressed that slowing of the cerebral blood-flow and varying degrees of cerebral anoxæmia should be regarded as the fundamental pathological processes following carotid ligation. These may lead to dilatation and increased permeability of the cerebral capillaries, resulting in œdema. Stasis and raised carbon-dioxide tension may be looked upon as features of a reduced blood-flow, but venous congestion and venous stasis, postulated by Brüning in addition to œdema as lesions underlying transient neural disorders, necessitate the assumption of an obstruction acting on the venous outflow. Neither anatomical nor physiological considerations can be cited in support of this theory.

c. **The Influence of Vascular Nerves.**—Since the discovery of nerves to the cerebral blood-vessels and the demonstration by H. S. Forbes and H. Wolff (1928) of changes in diameter of these vessels in animal experiments and by O. Foerster and W. Spielmeyer (1926) and W. Penfield (1933) in human material, the theory has been formulated that cerebral lesions after carotid ligation may be due to arterial spasm. Clinical observations on the behaviour of the retinal vessels after carotid ligation had been contradictory, and recent experimental evidence by H. S. Forbes and S. T. Cobb (1928) suggests that the narrowing of cerebral vessels in response to sympathetic stimulation cannot be a potent cause of cerebral ischæmia. These authors found the effect of sympathetic stimulation on the calibre of the cerebral vessels to be ten times less than the effect obtained in the peripheral vessels in the skin. The most potent mechanism affecting the diameter of cerebral vessels is the carbon-dioxide tension, and an accumulation of carbon-dioxide in consequence of a reduced blood-flow should have a vasodilating effect in excess of the hypothetical sympathetic vasoconstriction.

d. **The Carotid Sinus.**—A fall in blood-pressure due to the irritation of the carotid sinus was thought by Ask-Upmark (1935) to play some part in the production of neurological complications following carotid ligation. In 3 cases in which I investigated the blood-pressure during and after the application of a carotid ligature I could find no significant changes. Carotid sinus stimulation, however, may play an important part in the effects produced by digital compression of the carotid in the neck. This procedure, first advocated by R. Matas (1911), has been accepted as a pre-operative test of great importance. Its results appear to be fallacious. Digital compression is hardly ever applied for more than an hour at a time, yet grave signs of neurological damage appear commonly twenty-four hours and longer after the occlusion of the carotid. Many examples can be found in

the literature of patients who tolerated digital compression, but developed temporary or permanent hemiplegia after carotid ligation. On the other hand, carotid compression may cause unconsciousness and transient hemiplegia while carotid ligation may prove an entirely benign procedure in the same patient. Two different mechanisms seem to be involved in digital compression and in ligation, and the one can hardly be used as a fair pre-operative test for the other.

e. **Influence of Age.**—It has frequently been stated that in patients past middle-age carotid ligation is a much more dangerous procedure. The present series does not support this view. The accompanying graph (*Fig.* 38) and

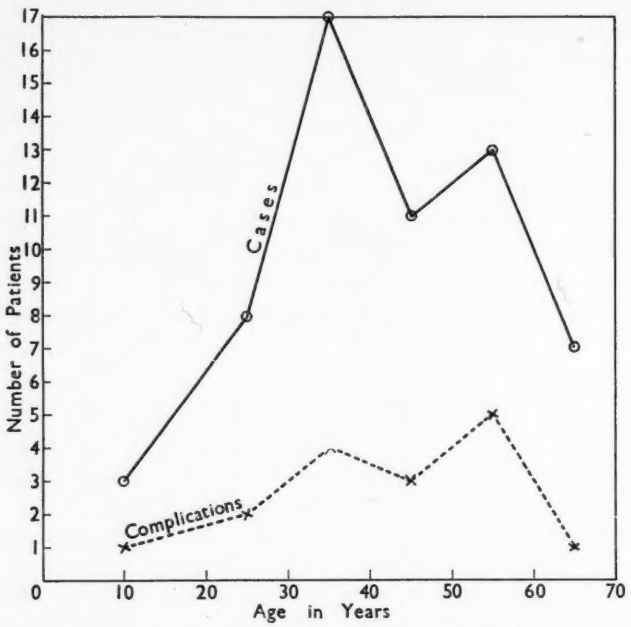


FIG. 38.—Graph showing age in relation to incidence of complications following carotid ligation.

Table II illustrate the fact that the incidence of post-operative complications does not increase materially with advancing age. Pilcher and Thuss (1934) investigated a hundred cases of hemiplegia after carotid ligation taken at random from the

Table II.—POST-OPERATIVE COMPLICATIONS OF CAROTID LIGATION IN RELATION TO AGE

AGE GROUP	NO. OF CASES	DEATHS	HEMIPLEGIAS	TOTAL
Under 20	3	0	1 (33·3 per cent)	1 (33·3 per cent)
20–29	8	1 (12·5 per cent)	1 (12·5 per cent)	2 (25·0 per cent)
30–39	17	1 (5·8 per cent)	3 (17·6 per cent)	4 (23·5 per cent)
40–49	11	2 (18·2 per cent)	1 (9·9 per cent)	3 (28·2 per cent)
50–59	13	4 (30·7 per cent)	1 (7·7 per cent)	5 (38·4 per cent)
60–69	7	0	1 (14·3 per cent)	1 (14·3 per cent)
Over 70	1	0	0	0
Total	60	8	8	16

literature; they did not find that age influenced the outcome of the operation. Small though my own figures are, they support the conclusion reached by these authors.

A quotation from the writings of Sir W. M. Bayliss may conclude this discussion. In 1895 he expressed the opinion that the "importance of the brain is such that its circulation is regulated by the rest of the body". It is the state of the "rest of the body" which has been stressed in this paper as being the determining factor in carotid ligatures. In the Manchester Neurosurgical Service this theoretical conception has been applied in the practical pre- and post-operative treatment of patients in whom a carotid vessel has been ligated. To facilitate the blood-supply to the brain, patients are kept in the Trendelenburg position for at least ten days after operation, and for another two to three weeks they are not allowed to sit up. Blood transfusions are given when necessary before and after the operation. Recent subarachnoid hæmorrhage is regarded as a contra-indication for carotid occlusion, and any operation on a supraclinoid aneurysm is made by a direct approach through the skull and not by ligature. If the progressive nature of the lesion or trigeminal pain warrant it, carotid ligation is considered the treatment of choice in all patients with infraclinoid aneurysms who are in good general health.

CAROTID LIGATION IN CONDITIONS OTHER THAN INTRACRANIAL ANEURYSMS

The special conditions which may complicate carotid ligation in cases of intracranial aneurysms have been stated. The cerebral circulation may, however, be impaired by other than local causes. Should the systemic blood-pressure fall, as after severe hæmorrhage or in traumatic shock, the volume or the rate of flow of blood in all organs of the body including the brain is reduced. Carotid ligation is therefore a dangerous undertaking in patients who have a lowered blood-pressure. Statistical facts support this statement. In the cases collected by Pilz (1868) ligation of one common carotid artery was carried out 285 times for hæmorrhage, and 52·6 per cent of these patients died. De Fourmestraux (1906) found the mortality figure in similar cases to be 54 per cent. H. Marschik (1926) lost 6 out of 8 patients with war wounds of the carotid vessels, and in 4 of these patients hemiplegia followed the ligature. H. Gollub (1936) describes 4 cases of carotid ligation performed for hæmorrhage due to septic or neoplastic erosion of the vessel wall. One of these patients died from hæmorrhage alone and showed no signs of a cerebral lesion. Another patient died nine days after ligation, having been hemiplegic since the day after operation. The remaining two ligatures were followed by temporary but grave neurological disorders. More favourable results were obtained by Sir G. H. Makins (1919) in his experience with war wounds involving the great vessels of the neck. Of 27 patients in whom ligature of a carotid artery had been performed, only 3 died, and in 8 (29·6 per cent) cerebral complications ensued.

Similarly, carotid ligation has a very high mortality when it is performed in patients who are suffering from a malignant growth, particularly if the carotid artery has to be ligated during the operative removal of the tumour. In cases of this type Pilz found a mortality of about 35 per cent, De Fourmestraux's figure was 46 per cent, and in a recent paper by Watson and Silverstone (1939)

the mortality after common carotid ligation was 54 per cent, and 70 per cent of their patients suffered cerebral damage.

The other indications for which carotid ligation has been frequently undertaken are extracranial aneurysms and pulsating exophthalmos. De Fourmestraux (1906) found a mortality of 13·5 per cent in extracranial aneurysms, and of 7 per cent in pulsating exophthalmos (Dandy, 1937, 8 per cent). The statistics dealing with the results of carotid ligation for all indications have remained surprisingly constant, and little if any differences exists between the figures collected in the pre-antiseptic era and more recent statistics.

The dependence of the results of carotid ligation on the general state of the individual, his blood-pressure, and blood-volume is clearly seen if the foregoing mortality figures are compared with a series of cases in which carotid ligation was performed in the first half of the last century for ' nervous disorders ', e.g., epilepsy, trigeminal neuralgia, etc. Pilz collected 34 cases of this type and quoted the earlier statistics of Norris and of Velpeau. There were 45 patients in this group, and their general health may be assumed to have been good, although one or the other may have had a cerebral tumour. Only 1 of these 45 patients died, i.e., 2·2 per cent. These 45 carotid ligations can be legitimately regarded as human experiments on the effects of ligature of the common carotid artery in normal persons, and in such individuals the procedure is attended by little danger. My own figures on the results of ligation in infraclinoid aneurysms support this view. According to G. M. Dorrance (1934), occlusion of the common carotid reduces the blood-flow in the internal carotid on the same side by 50 per cent. In a normal person this deficit can be compensated for by the intracranial collateral circulation. Occlusion of one internal carotid should be tolerated without ill effects by an individual whose general health is good.

The low mortality in cases of this type must serve as a base-line for all comparative investigations on the results of carotid ligation. In the past the mortality has been thought to be lower in carotico-cavernous aneurysms, and theories have been advanced to explain this (W. E. Dandy, 1937). The mortality in these cases is about 8 per cent, a very favourable figure if compared with the 45 per cent mortality in ligatures for hæmorrhage, but eight times worse than the results of ligature in non-fistulous aneurysms. It cannot be true, therefore, as has so often been stated, that the presence of a carotico-cavernous aneurysm improves the collateral circulation through the circle of Willis, thus preparing for the occlusion of one carotid artery.

The results of carotid ligation performed for indications other than intracranial aneurysms can be explained if the pre-operative state of the cerebral circulation is taken into account. If carotid ligation must be undertaken as an emergency measure in a patient who has lost blood or is suffering from shock, blood transfusions should go far towards improving the results of ligation in military practice.

SUMMARY

1. The results of carotid ligation in 60 cases of saccular intracranial aneurysm have been analysed.

2. In patients with infraclinoid aneurysm carotid ligation has proved to be a uniformly benign procedure.

3. The highest mortality and incidence of post-operative cerebral complications were found in supraclinoid aneurysms complicated by recent subarachnoid hæmorrhage or local compression of basal arteries by the aneurysm.

4. Neural damage after ligation arises from : (*a*) Failure of the systemic circulation on which the cerebral circulation so much depends ; (*b*) Local interference with the circulation of the brain by the lesion for which the ligation has been undertaken.

5. The histological features of the lesion depend on the mechanism by which they are produced. They appear as varying degrees of localized or diffuse anoxæmic damage. The cerebral arteries do not contain clot.

6. The commonly accepted theory of post-operative embolism occluding the cerebral circulation has been shown to have no foundation in fact.

It is my pleasant duty to record my sincere gratitude to the Society of British Neurological Surgeons for their kind permission to use these cases for the present paper, and for the trouble they have taken in communicating their material to me.

BIBLIOGRAPHY

ABERNETHY, J., *The Surgical and Physiological Works of John Abernethy*, 1830, **II**, 117. London.
ADACHI, B., *Das Arteriensystem der Japaner*, 1928, **I**, 115. Kyoto.
ALBRIGHT, F., *Bull. Johns Hopkins Hosp.*, 1929, **44**, 215.
ASK-UPMARK, E., *Acta Psychol. et Neurol.*, 1935, supp. 6.
BAYLISS, Sir W. M., *Jour. of Physiol.*, 1895, **18**, 334.
BIRLEY, J. L., and TROTTER, W., *Brain*, 1928, **51**, 184.
BRÜNING, F., *Deut. med. Woch.*, 1926, **52**, 145.
CAUCHOIX, A., *Bull. et Mém. Soc. de Chir.*, 1922, **48**, 2.
COOPER, Sir A., *Med.-Chir. Trans. Lond.*, 1812, **I**, 1.
COOPER, Sir A., *Guy's Hosp. Rep.*, 1836, **I**, 53.
DANDY, W. E., *Zentralb. f. Neurochir.*, 1937, **2**, 77.
DANDY, W. E., *Ann. of Surg.*, 1938, **107**, 654.
DANDY, W. E., *Ibid.*, 1939, **109**, 689.
DAVIES, E. D. D., *Brit. Med. Jour.*, 1939, **I**, 721.
DE FOURMESTRAUX, J., *Thèse de Paris*, 1906–7, **292**, 1.
DÖRING, G., *Virchows Arch.*, 1936, **296**, 666.
DORRANCE, G. M., *Ann. of Surg.*, 1934, **99**, 721.
DOTT, N. M., *Edin. Med. Jour.*, 1933, **40**, 219.
FLEMING, D., *Med.-Chir. Jour.*, 1817, **3**, 2.
FÖRSTER, G., and SPIELMEYER, W., *Deut. Zeits. f. Nervenheilk.*, 1926, **94**, 15.
FORBES, H. S., and COBB, S. T., *Proc. Assoc. Res. Nerv. and Ment. Dis.*, 1938, **18**, 201.
FORBES, H. S., and WOLFF, H. G., *Arch. of Neurol. and Psychiat.*, 1928, **19**, 1057.
LE FORT, L., *Gaz. hebd. de Méd. et Chir.*, 1868, **5**, 437.
FURTADO, D., *Rev. neurol.*, 1938, **69**, 523.
GOLLUB, H., *Münch. med. Woch.*, 1936, **88**, 1827.
GRIFFITHS, C. A., *Brit. Jour. Surg.*, 1915, **3**, 302.
HERMANN, K., OBRADOR, S., and DOTT, N. M., *Lisboa méd.*, 1937, **14**, 782.
HILL, T. R., *Proc. Roy. Soc. Med.*, 1938, **31**, 215.
HOMANS, J., *Arch. of Surg.*, 1929, **18**, 992.
JEFFERSON, G., *Brain*, 1937, **60**, 444.
JEFFERSON, G., *Brit. Jour. Surg.*, 1938, **26**, 267.
MCCONNELL, A. A., *Zentralb. f. Neurochir.*, 1937, **5–6**, 269.
MCKENDREE, C. A., and DOSHAY, L. J., *Bull. N.Y. Neurol. Inst.*, 1936, **5**, 223.
MCLEAN, A., *Surg. Gynecol. and Obst.*, 1915, **20**, 457.
MAGNUS, V., *Jour. Amer. Med. Assoc.*, 1927, **88**, 1712.
MAKINS, Sir G. H., *Gunshot Injuries to the Blood-vessels*, 1919. Bristol.
MARSCHIK, H., *Deut. Zeits. f. Chir.*, 1926, **198**, 330.
MATAS, R., *Ann. of Surg.*, 1911, **53**, 1.
MILLER, R. H., and ROGERS, H., *Jour. Amer. Med. Assoc.*, 1929, **93**, 1452.
MONIZ, E., *Revue neurol.*, 1927, **2**, 72.
MONIZ, E. *Zentralb. f. Neurochir.*, 1938, **3**, 217.

MÜLLER, G., *Zeits. f. d. g. Neurol. u. Psychiat.*, 1930, **124**, 1.
NATTRAS, F. J., *Edin. Med. Jour.*, 1928, **35**, 30.
NORRIS, quoted by PILZ.
PENFIELD, W., *Ann. of Internal Med.*, 1933, **7**, 303.
PERTHES, *Arch. f. klin. Chir.*, 1920, **114**, 403.
PILCHER, C., and THUSS, C., *Arch. of Surg.*, 1934, **29**, 1024.
PILZ, C., *Arch. f. klin. Chir.*, 1868, **9**, 257.
REINHARDT, A., *Mitteil. a. d. Grenzgeb. d. Med. u. Chir.*, 1913, **24**, 432.
SIEGRIST, A., *Arch. f. Opthalmol.*, 1900, **50**, 511.
SJØQVIST, O., *Nervenarzt*, 1936, **9**, 233.
SPIELMEYER, W., *Histopathologie des Nervensystems*, 1922, 1. Berlin.
TRAVERS, B., *Med.-Chir. Trans.*, 1813, **2**, 1.
TWITCHELL, A., *New Eng. Quart. Jour. Med.*, 1843, **1**, 188.
DE VET, A. C., and ZECKEL, A., *Nederl. Tijds. v. Geneesk.*, 1937, **81**, 4145.
VELPEAU, quoted by PILZ.
VINCENT, C., THIEBAUT, F., LEMOYNE, J., and GUILLAUMAT, L., *Revue neurol.*, 1937, **67**, 361.
WALSH, M. N., and LOVE, J. G., *Proc. Staff Meet. Mayo Clinic*, 1937, **12**, 81.
WALSH, M. N., and LOVE, J. G., *Ibid.*, 1939, **14**, 122.
WATSON, W. L., and SILVERSTONE, M., *Ann. of Surg.*, 1939, **109**, 1.

THE END-RESULTS AND TREATMENT OF TUBERCULOUS DISEASE OF THE ANKLE AND TARSUS

By W. R. D. MITCHELL

Tuberculous arthritis of the ankle, although it has received scant attention in the literature, nevertheless ranks fourth in the order of frequency with which the larger joints are affected.

Most of the articles are inconclusive because of the failure of the authors to distinguish between the condition occurring in childhood and in adult life, and few rules for treatment are laid down beyond general recommendations as to the special advantages of conservative or operative methods.

Sever analysed 213 cases of tuberculosis of the ankle, and decided that results were better with conservative treatment than with operation, in spite of the fact that the type of conservative treatment adopted did not include recumbency. In Sever's opinion also, the rapidity of secondary involvement of other joints was found to be increased with operation.

Rogers, who traced 17 adult cases, found that treatment by fixation only gave good results in 3 patients, while in 9 others resection of the joint was performed, and in the case of 8, amputation was eventually necessary. He naturally advises early resection or amputation, but gives no indication to show which method should be employed.

Gaenslen and Schneider advocate that in the adult treatment should include at least six months' trial of conservative measures, and state that amputation and death from other forms of tuberculosis are frequent, because conservative measures are persisted in for too long a period.

Syring, in an analysis of 222 cases of adults and children together, found that conservative measures sufficed in 108 and local excision of the disease was necessary in 114, followed by amputation in 45.

Maas states that conservative treatment is contra-indicated in all adult patients in whom a focus of bone infection can be demonstrated, but agrees with conservative treatment for children.

Sprengler, in a series from Kocher's clinic, found that 48 per cent of patients suffering from tuberculous disease of the ankle died within ten years.

In general, most writers agree that children suffering from this disease should be treated conservatively, while adult patients are more successfully dealt with by operation, but no distinction is drawn between amputation and other less radical measures.

No writer, in dealing with the treatment of the disease in children, distinguishes between the several forms of the disease, some of which are with advantage treated operatively, while in others operation is likely to retard healing or even spread the infection. It is hoped in the following analysis to make this point clear.

Regarding the treatment of adults, opinion is divided. There is undoubtedly an increasing tendency to employ operative measures, but amputation is usually

delayed until its full benefit cannot be realized. Excision is a failure at any period of the disease, for reasons which will be given later.

I propose to deal with the treatment of adults and young patients separately, and to endeavour to show that different methods of treatment influence the duration of the disease and the end-result, especially in children.

In this paper I have been able to review 169 patients, and of these, the progress of 77 children and 45 adults has been followed for a minimum period of three years from the cessation of treatment. Great difficulty has been experienced in obtaining sufficient patients treated under standardized methods to draw definite conclusions on certain points, and while the writer has gained some very strong impressions, it is, unfortunately, not always possible to show conclusive figures.

The results of treatment by short-period intermittent immobilization in recumbency, and treatment in non-weight-bearing ambulant splints, are, however, so obviously inferior to those where full initial immobilization in recumbency has been employed, that cases have been grouped under two headings in the children's series, to demonstrate this point.

Only disease of the ankle and tarsus has been considered, as it is felt that tuberculosis of the lower ends of the tibia and fibula, as well as that of the metatarsals and phalanges, constitute different problems.

The cases under review have been drawn from all the accessible hospitals around Liverpool, and cover periods as far back as 1913, when an entirely different attitude was adopted towards treatment.

The writer is fortunate in being able to see these cases from a purely impersonal viewpoint, as all were treated before his association with the hospitals concerned.

CHILDREN

Patients under 17 years of age at the commencement of the disease are classified as children, although in some of the adult cases there is a doubtful history of a childhood infection which has remained quiescent for many years.

Experience of the treatment of tuberculous arthritis of the ankle has shown clearly that the reaction of the patient and the course of the disease depends on the age of the patient. In most children, if the disease is efficiently treated in the early stages, a good result with a usable foot may be anticipated, irrespective of tuberculous lesions elsewhere. New tuberculous joint infections often make their appearance even when the primary lesion is in the terminal stages of healing. One would think that the bodily resistance at this time would be high, and as yet no adequate explanation has been given for this phenomenon.

Infection of the hip or knee-joint not infrequently appears whilst the patient suffering from tuberculous arthritis of the ankle has been walking for weeks or months, but the added infection, while it reduces the general condition, fortunately does not seem to have any effect on the ankle-joint, which proceeds to normal healing.

An illustration of this complication was provided by the case of one child who, following discharge from hospital with a healed ankle-joint infection, returned some months later with tuberculous disease of the hip-joint. This necessitated a further two years in hospital, but the ankle-joint remained healed and gave no further trouble.

The duration of disability varies with the general condition and the treatment given, but apart from these two factors it seems possible to recognize several forms of the disease, which run different courses and show different end-results.

Recognition of these forms will enable us to give a more accurate prognosis and to improve treatment. As an example, the tuberculous cyst of the os calcis usually heals completely and remains healed without infecting any articulation, but tuberculosis of the subastragaloid joint remains active much longer and is always liable to spread to adjacent articulations. It has also the great disadvantage that it is extremely difficult to tell when healing is complete, and the patient must be kept under observation for a period of years, whereas in the case of a calcanean cyst radiographic evidence of healing is to be trusted, and the patient can be confidently discharged.

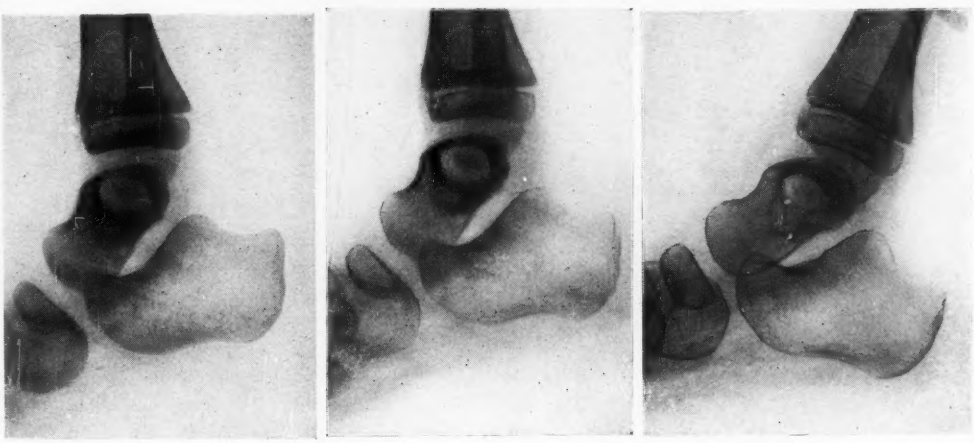
In the children's series cases have been grouped under headings to illustrate three forms of disease : (*a*) Extra-articular disease ; (*b*) Synovial disease ; (*c*) Intra-articular disease.

***a*. Extra-articular Disease.**—The infection here may be situated in the soft tissues as a bursitis, tenovaginitis, or superficial abscess, or in the bony structure as a localized bone abscess. This latter, which forms the large proportion of extra-articular infections, is usually situated in the os calcis and is often of the encysted type. Occasionally it occurs in the astragalus or cuboid.

Eighteen cases, or 23·5 per cent, fell into this category, and without exception the results were good.

Immobilization in recumbency with a right-angled foot splint is the usual treatment given, except in the few localized soft-part lesions, such as a bursitis or tenovaginitis, where a clean removal of the diseased tissue is the method of choice.

In one case where an encysted focus in the calcaneum was cleared out operatively, the duration of disability was 48 months as opposed to the average duration of 13 months for the patients treated conservatively. An illustration of this type of case is provided by the radiographs (*Fig.* 39) of a focus in the astragalus.



A B C

FIG. 39.—Tuberculous cyst of the astragalus in a boy aged 6. Astragalectomy was considered, but complete healing followed 14 months' immobilization in bed. A, June 6, 1933, disease active; B, Jan. 7, 1934, commencing recalcification; C, Nov. 20, 1937, disease arrested with no disability.

Had astragalectomy been performed, the result would have been poor compared with that obtained from conservative treatment.

b. **Synovial Disease.**—Eight cases, or 10·3 per cent, were classed as true synovial disease. In every instance a generalized decalcification of the foot bones could be seen, combined with marked synovial thickening. No focus of bone erosion was ever detected, and the result in all patients was good.

All except two of the patients were treated with adequate initial immobilization in recumbency, with an average period of disability of 10·5 months. In the two patients who were treated intermittently for short periods the duration of disability was 43 and 48 months.

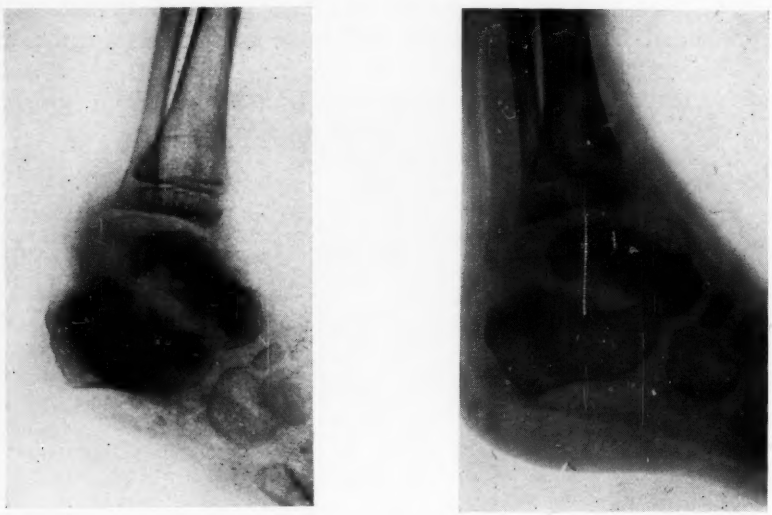
The common intra-articular form usually starts as a synovial thickening, without radiographic signs of bone erosion, and if the cases listed here as 'synovial' had not been treated in time, many would have probably developed a true bone erosion. It seems probable that adequate treatment can limit the infection to the synovia, without involving bone, as the majority of synovial cases in this series came from one institution.

The incidence of synovial disease will be found to be highest where treatment is best.

c. **Intra-articular Disease.**—Sixty-six per cent of cases come under this heading. The actual site of infection in this form seems to have no bearing on the duration of the disease or on the resulting deformity.

Thirty-six cases showed an infection of the ankle-joint, while of these 26 showed no adjacent joint infection, but the remaining 10 had an additional involvement of the posterior compartment of the subastragaloid joint.

The other intra-articular infections showed the following distribution: Astragalo-scaphoid and anterior half of subastragaloid, 4; Anterior tarsus, 4; Generalized tarsal infection, 6; Cuboid and outer tarsus, 1.



A B

FIG. 40.—Tuberculous arthritis of subastragaloid joint in a boy aged 4. A, Sept. 12, 1931, disease active; B, May 17, 1932, almost normal appearance after 8 months' immobilization in bed.

Fig. 40 shows a heavily infected subastragaloid joint; the boy is now captain of his school junior football team. Severe destruction of the scaphoid (*Fig.* 41) treated conservatively, has left a painless foot hardly distinguishable from the normal.

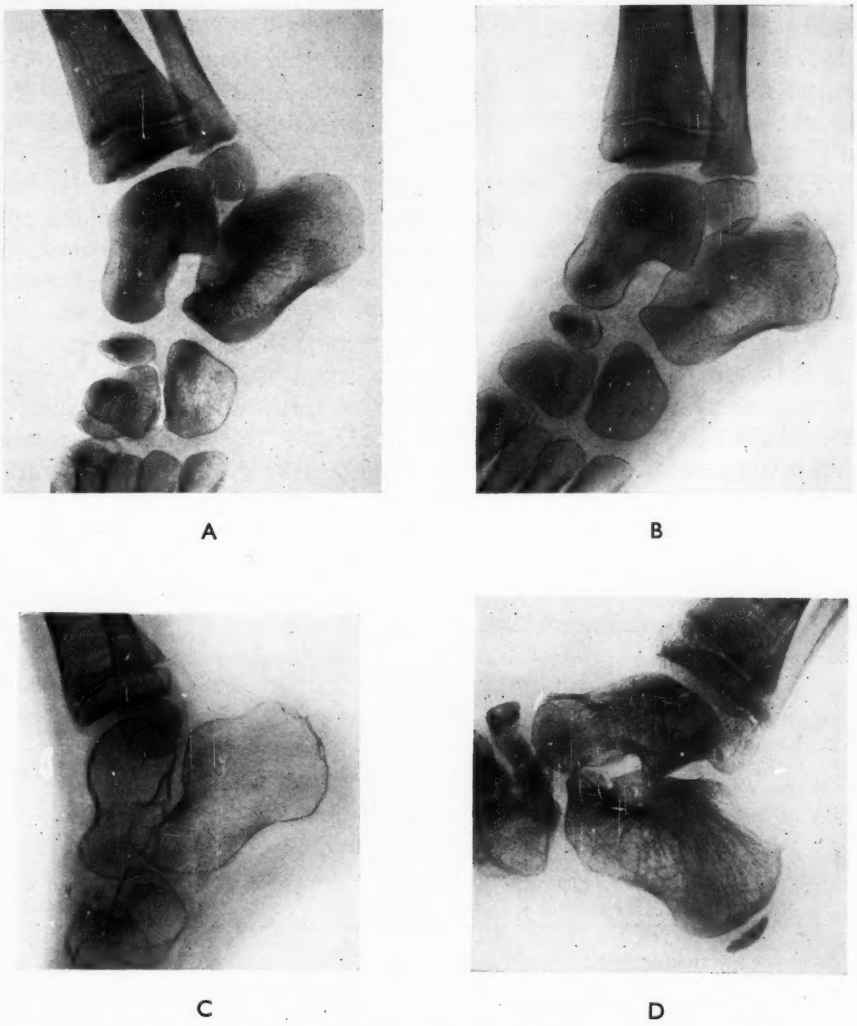


FIG. 41.—Tuberculous osteitis of the scaphoid, first thought to be a case of Köhler's disease. A–C, Showing progressive destruction (A, Sept. 24, 1935; B, Nov. 15, 1935; C, Jan. 10, 1936); D, Nov. 6, 1937, disease arrested, with no disability, following 14 months' immobilization.

Sinus Formation.—This was present in 71 per cent of patients, but in spite of this, subsequent bony ankylosis occurred in only two instances. In the face of results one must conclude that a sound fibrous ankylosis is no disability.

It is often taught that secondary infection of a joint leads to bony ankylosis, and while this may be true in other situations, such is not usually the case in the ankle-joint.

Superficially, these different forms of the disease may have the appearance of various stages of the same process, and to a certain extent this is true. Intra-articular disease almost certainly passes through a stage when the synovial membrane is thickened but no bone erosion can be demonstrated radiologically. The synovial form of the disease, however, may not advance to bone destruction if under adequate treatment, and obviously the end-result is much better if the disease can be checked before erosion of the joint occurs.

The extra-articular form with localized bone infection does not proceed to joint infection under conservative treatment, but operation, with a view to excising the focus of infection, may have the effect of spreading the disease locally and to distant parts of the body.

In *Table I* the results of the three forms of the disease have been grouped, with statistics as to the duration of the disease and the type of treatment employed.

Those under ' adequate treatment ' have had one long period of immobilization in recumbency at the outset, usually by means of the right-angled foot splint.

Those under ' inadequate treatment ' have not been seen at the onset of the disease, or have had several relatively short periods of immobilization in bed. Some of the patients were treated during the Great War, when beds were required for more urgent cases, and when the value of long recumbency was not fully realized. Results are classed under three headings: Good, disease arrested with no disability; Fair, disease arrested with some disability; Bad, disease still active, amputations and deaths.

Table I.—End-results and Duration of Disability in Patients less than 17 Years of Age at the Commencement of the Disease

	No. of Cases	Good	Fair	Bad	Average Duration
		per cent	per cent	per cent	months
Adequate Treatment:					
Extra-articular	17	100	0	0	13
Synovial	6	100	0	0	10·5
Intra-articular	22	95	5	0	17
Inadequate Treatment:					
Extra-articular	1	100	0	0	48
Synovial	2	100	0	0	45·5
Intra-articular	29	65	10	25	51 (53, including amputations and deaths)

Comment is unnecessary with regard to the figures concerning extra-articular and synovial disease in the above table, but the great variation in the periods of disability of intra-articular disease under different methods of treatment is most marked. All the ' bad ' results are attributed to lack of proper treatment, and an analysis of these shows:—

Eventual amputation	6 cases
Death following amputation	1 case
Still active	1 case

Of the patients with some disability, 3 had deformity from loss of bony structure and 1 had developed an equinus deformity from an ankle-joint infection.

Treatment: Conclusions.—Treatment of children, with the exception of the few cases outlined already, should be entirely conservative.

The method of immobilization most favoured is the right-angled foot splint or crab splint. The foot is retained in the splint with encircling bands of adhesive strapping, over which a firm bandage is applied for additional immobilization. With this appliance the skin is kept in good condition, and abscesses may be detected in the early stages. Objections to immobilization with a plaster cast are that it excludes all air and light, and unsuspected abscesses are often found on its removal.

Radiographs are taken monthly for the first three months, and thereafter every four months until no further increase in re-calcification can be detected.

Radiographs are always inspected as a series, as it is not considered that one alone can show whether the disease is increasing or decreasing in activity.

When it is judged that re-calcification is complete, a further six months' recumbency is always desirable before putting the limb to the test.

Sunlight.—No great stress is laid on sunlight as a means of treatment, but in the summer months carefully graded doses of natural light are given as a general tonic. Local heliotherapy is not considered to be of any value.

Tuberculin.—Many patients have been given tuberculin, as a means of both diagnosis and therapy, but results were so inconclusive that its use has now been abandoned.

Sinuses.—The management of sinuses is quite a problem in itself, and while every effort is made to prevent their occurrence, they appear in the majority of cases. (In this series they appeared in 71 per cent of patients.) They are not regarded as a complication, nor do they seem to retard healing. The sinus which persists after the bone is well sclerosed is probably due to a local osteomyelitis, but in the majority of cases the sinus is regarded as a sign of activity.

It has been suggested that a discharging sinus may actually assist healing by providing an exit for tuberculous material, but no conclusive evidence on this point can be given.

When an abscess appears it may subside following aspiration, but, fortunately or unfortunately, according to the view held, a sinus usually develops.

In pure tuberculous disease the temptation to enlarge a sinus and scrape out material must be resisted, because shortening of the period of disability never results from this procedure, which should be performed only when a super-added osteomyelitis with sequestrum formation is present.

The sinus is kept carefully covered with sterile gauze until healing takes place. When discharge is profuse the use of medicated sawdust has been found useful as an absorbent and deodorant.

Diagnosis.—Diagnosis has always been made on clinical and radiological grounds alone, except in a few cases treated operatively, where a pathological examination of the excised tissue was performed. Biopsy is not justifiable, on account of the danger of sinus formation and the risk of local and distant spread of infection. In cases where an immediate diagnosis is not possible, a period of observation under full treatment should be carried out until the condition clears or becomes manifest.

ADULTS

No similarity can be drawn between this and the preceding section. The end-results in the 45 adult cases followed are as gloomy as those in the children's section are encouraging. Out of this number, only 12 patients, or 27 per cent,

were able to go back to work with the disease cured, and there is no guarantee that these ankles will remain permanently healed. It is considered that a follow-up over a longer period than has been possible here would show an even smaller percentage of cures.

In one case, that of a man who was 60 years of age when symptoms first appeared, it was found that at the age of 12 he had been treated for several years for a discharging ankle which was almost certainly tuberculous. The man had worked as a labourer for over 44 years without symptoms, but with latent infection all the while.

No clear-cut distinction of the various forms is possible in adults, as it is in children, although the superficial form of disease may be seen occasionally.

An attempt has been made to assess the results of the various forms of treatment, but so often a combination of methods had been used that figures on one particular method become very difficult to obtain.

Adequate conservative treatment is rarely possible in adults for many reasons. Few patients will stand the strain of absolute inactivity even for one year, and many, for their own reasons, will not consider such a suggestion.

In some districts it is not possible to obtain hospital accommodation for the patient, and treatment becomes a compromise, with numerous small operations and intermittent immobilization.

Commonly, if amputation is decided upon, it is delayed until its full benefit cannot be realized.

The disease is insidious and therein lies its danger. It is easy to understand the difficulty of impressing upon the patient, who only complains of a slight ache in the ankle-joint, that amputation is necessary.

Faced with these difficulties, it is little wonder that the results of treatment are so bad.

In the subsequent analysis an attempt will be made to show that conservative treatment should be tried only for a limited period, and if the response is not satisfactory, amputation should be performed without further delay.

By early amputation the duration of the disease is shortened to a fraction of the time, the chances of a secondary focus are considerably reduced, and the patient is free from the mental strain imposed by a prolonged illness.

The mental state which exists in these patients is best appreciated by studying patients in the late stage of the disease. When amputation is performed as a last resort, the immediate improvement which follows in the great majority of cases is usually attributed to the removal of the septic focus, but the disease, which by this time has established itself elsewhere, often kills the patient in a matter of months.

No figures are available to show the incidence of metastatic infection, but inquiry in the appropriate institutions has elicited the interesting fact that bone infection, following a primary pulmonary lesion, is much less frequent than pulmonary infection following a primary bone lesion.

It is the author's strong belief that the less radical operations, such as scraping, excision, astragalectomy, and arthrodesis, have no place, and serve only to prolong the period of disability and endanger life. Too many patients die with tuberculous foci elsewhere, and some of these could probably be saved by early amputation.

ANALYSIS OF RESULTS

Age.—All ages from 17 to 70 were equally affected, and the only point of interest to be gained from an examination of the cures in relation to age is that no cure was recorded over the age of 42. Seventeen patients over the age of 42 were treated, the oldest being 74 years of age. The deduction from this finding is obvious, and there should be no hesitation in considering the question of amputation in patients over 45 years of age.

For the sake of emphasis, it is repeated that in adults, and especially in elderly patients, the disease should be considered as malignant and treated as such.

Site and Form of Infection.—In four patients the superficial form of the disease without bone infection was noted. As in the case of children, these all did well and were classed as cures. The rest, with one exception, were all intra-articular lesions with evidence of bone erosion. The one exception was an encysted focus in the astragalus, upon which an astragalectomy had been performed. Even in this case, where the disease was apparently eradicated, amputation became necessary ten months later on account of spreading infection with joint involvement. Probably with rigorous conservative treatment a cure could have been obtained.

The site of joint erosion is unimportant and appears to have little bearing on the result, but out of interest the distribution is given below.

Table II.—Distribution of Intra-articular Infections and Results

	Ankle-joint Alone	Ankle-joint and Sub-astragaloid	Astragalo-scaphoid and Sub-astragaloid	Anterior Tarsus	Cuboid and Outer Tarsus	Generalized Infection
Disease arrested	4	1	1	1	1	0
Disease not arrested	11	10	2	5	3	1

Relation of Treatment to the End-result.—For the purpose of this article treatment has been divided into three types :—

1. Conservative. The patient is treated by immobilization in recumbency, or in an ambulant splint, until he is cured, dies, or is eventually subjected to a late amputation.

2. Local operative treatment. This is used to cover all surgical procedure less than amputation, i.e., arthrodesis, excision, astragalectomy, and scraping.

3. Early amputation, i.e., within twelve months of the commencement of the disease, before gross infection has occurred.

Table III.—Showing Relationship of Treatment to End-results in Adult Cases

	No. of Patients	Cures	Still Active	Died from the Infection	Living following Late Amputation	Died following Late Amputation
Conservative treatment	23	10	2	7	3	1
Local operative treatment	8	2	2	–	4	–
Early amputation	14	Living with reasonable expectation of life				13
		Died subsequent to amputation				1

Results are tabulated under these three headings, and while all cures must of necessity fall into the first two groups, it is from a consideration of the failures that most information is to be gleaned (*Table III*).

Conservative Treatment.—Attention is drawn to the fact that out of the 10 recorded cures from conservative measures alone, only 6 were true instances of tuberculous arthritis. In the remaining 4 cases infection was confined to the soft tissues, where treatment is much more likely to be effective.

The poor results shown by these figures for conservative treatment in the adult is due to the fact that many of these patients were wholly unsuited for this line of treatment.

If these 23 patients had all been reviewed at the end of six months' trial of conservative treatment, and if amputation had been performed on those who were not showing a definite resistance to the infection, it is safe to say that the mortality would have been less and the percentage of cures by conservative treatment increased.

Local Operations.—Whatever procedure is adopted, the aim is the same—namely, eradication of the disease. Local excision is intended to do this directly, arthrodeses indirectly by internal splintage, and scraping by the acceleration of a natural process.

Arthrodesis is perhaps the most popular of these operations, because of its success in the treatment of other joints, notably the knee-joint. In the ankle-joint, however, two factors are present which greatly reduce the chances of healing following such a procedure.

First and most important is the proximity of other synovial compartments which can easily become infected, if not already the site of a subclinical infection at the time of operation.

The subastragaloid and midtarsal joints must be included in the possible field of tuberculous activity, and in the early stages it is impossible to say whether or not they are likely to become the site of an active erosion. An examination of the radiograph cannot exclude an infection of the subastragaloid joint, nor may the joint be tested clinically on account of the generalized swelling and rigidity. The astragalo-scaphoid and calcaneo-cuboid joints are similarly placed.

Secondly, bony ankylosis is much more difficult to secure in the ankle than, for instance, in the knee, and in the event of failure a recrudescence of the infection is likely. Even if the arthrodesis is successful it does not take into account the essentially diffuse nature of the infection, and too often, following operation, the subastragaloid or astragalo-scaphoid joint begins to show signs of tuberculous invasion.

A cure obtained by a single arthrodesis of this type is more a matter of good luck than good judgement.

Excision of the focus, irrespective of joint compartments, as practised by Miltner and Fang, is open to the same objections as arthrodesis. The diffuse infiltration is not considered, and a subclinical infection is likely to be left in proximity to a synovial compartment.

The eight patients treated by local operation were all found to be living within three years of the commencement of the disease, but it must be remembered that half of these were subjected to amputation as soon as the re-activation became apparent.

All the amputations here were performed within sixteen months of the onset of infection, and therefore could almost be classed as early amputations.

The Argument for Early Amputation.—Out of 23 patients treated conservatively, 8 died with tuberculous disease elsewhere. In other words, approximately 35 per cent died, and all were found to have secondary tuberculous lesions in other parts of the body.

Fourteen patients were treated by early amputation within one year of the commencement of the disease. Thirteen of these were found to be living, all with a reasonable expectation of life. One had died from secondary tuberculous disease.

The patients treated by early amputation were in all probability instances of acute infection, for in the institution where the majority of the adult patients were treated the value of early amputation had not been recognized for long.

Two points are emphasized: (1) Adults with a tuberculous ankle die, not directly from the ankle-joint infection, but from tuberculous lesions in other parts of the body which appear subsequent to the ankle infection; (2) None of the patients who have had an early amputation, with one exception, have developed serious secondary lesions.

Summarizing the benefits to be derived from early amputation, we have the following: (1) The period of disability is shortened; (2) The primary lesion is removed and secondary infection prevented; (3) Worry and mental changes produced in the patient by a long illness are absent; (4) The mortality is lowered; (5) Hospital accommodation and expense are less.

Plan of Treatment.—In patients over 45 years of age amputation should be performed through the upper tibia without delay.

In patients aged 17 to 35 there should be six months' trial of conservative treatment by immobilization of the ankle in recumbency in an open-air hospital. If the lesion then shows definite signs of healing, a further period may be prescribed under strict observation all the while. If at any time progress becomes arrested for more than three months, amputation should be performed immediately.

In patients aged 35 to 45 amputation should be considered if there is any doubt as to the patient's general condition. One should never wait for casts in the urine and other signs of general infection.

I wish to thank Professor T. P. McMurray for much helpful criticism and advice, as well as the hospital staffs, without whose aid I should not have been able to obtain the material for this article.

BIBLIOGRAPHY

ELS, *Beitr. z. klin. Chir.*, 1913, **87**, 51.
GAENSLEN, F. J., and SCHNEIDER, C. C., *Jour. Amer. Med. Assoc.*, 1921, **77**, 1168.
GIBNEY, V. P., *Trans. Amer. Orth. Assoc.*, 1900, **13**, 225.
HIBBS, R. A., *Jour. Bone and Joint Surg.*, 1930, **12**, 749.
HUMPHRIES, R. E., and DURHAM, H. A., *Jour. Amer. Med. Assoc.*, 1917, **68**, 282.
KOCHER, *Arch. f. klin. Chir.*, 1883, **32**, No. 2.
MAAS, *Ibid.*, **65**, 182.
MILTNER, L. J., and FANG, H. C., *Jour. Bone and Joint Surg.*, 1936, **18**, 287.
ROGERS, M. H., *Boston Med. Surg. Jour.*, **164**, 811.
SEVER, J. W., *Jour. Amer. Med. Assoc.*, 1910, **55**, 2128.
SHORT, A. R., *Index of Prognosis*, 1931. Bristol: John Wright & Sons.

SPONTANEOUS FRACTURE OF THE APPARENTLY NORMAL FIBULA IN ITS LOWEST THIRD

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The condition under consideration is of some importance, in spite of its seeming rarity, because it is very readily overlooked, especially as no examples appear to have been described in the literature. The following two cases are therefore considered to merit report.

CASE REPORTS

Case 1.—The patient was an unmarried woman, aged 61, whose occupation, that of assisting her parson brother in the work of a poor parish, involved much walking. Six weeks before examination she had noticed the spontaneous onset of swelling of the left foot and ankle, with some pain referred to the outer part of the leg. She sought advice because the pain had become worse during the last week. She was sure that there had been no injury of any kind. On examination, œdema of the feet, ankles and legs was found, without any cardiac, renal or pelvic cause. The œdema was more pronounced in the left lower limb than in the right; and about an inch and a half above the tip of the left external malleolus there was a localized area of tenderness over the fibula, which was thickened at this spot. Radiographs showed that the thickening was due to the presence of a ring of poorly calcified callus surrounding a slightly oblique irregular fracture which was not very readily discernible (*Fig.* 42).

An adhesive elastic bandage, applied from the base of the toes to the mid-calf, gave complete relief, and was retained for a period of six weeks, at the end of which it was discarded without any return of symptoms, although slight localized tenderness remained. After a further month there were no symptoms or abnormal signs. Further radiographs, taken respectively five and eight weeks after the first, showed better calcification of the callus and better definition of the fracture (*Fig.* 43). A month later the external callus had become organized, but the fracture was still discernible. At the present time, two years and a half after the patient was first seen, she is still free from symptoms.

Case 2.—The patient was a public school boy, aged 17, an enthusiastic runner. Five weeks before examination he went for a run. After covering four miles he halted for about three minutes' rest. On resuming he felt some stiffness in the right leg, and after about two miles he was obliged to walk; the leg was diffusely tender. Next day it was very stiff, somewhat swollen, and very tender in the lower six inches or so; weight-bearing was painful, and consequently he limped. Next day he forced himself to walk five miles in the hope of relieving the stiffness, and he felt that the leg was perhaps slightly better, so that on the following day he played a game of Rugby football, which he managed to finish after a fashion although soreness of the leg became apparent within the first two minutes. On medical advice he restricted his activity to short walks. A week later he could walk with moderate comfort, but swelling and stiffness were still present; about this time the swelling and tenderness became localized to the fibular region, about three inches above the ankle. Three weeks after the onset of symptoms, he struck the leg against a chair, when 'ragging'; this made the leg temporarily very painful, but on the whole seemed to improve it, so that a week later he could run half a mile. Localized swelling and tenderness remained. He felt certain that he had not injured his leg in any way before the onset of symptoms.

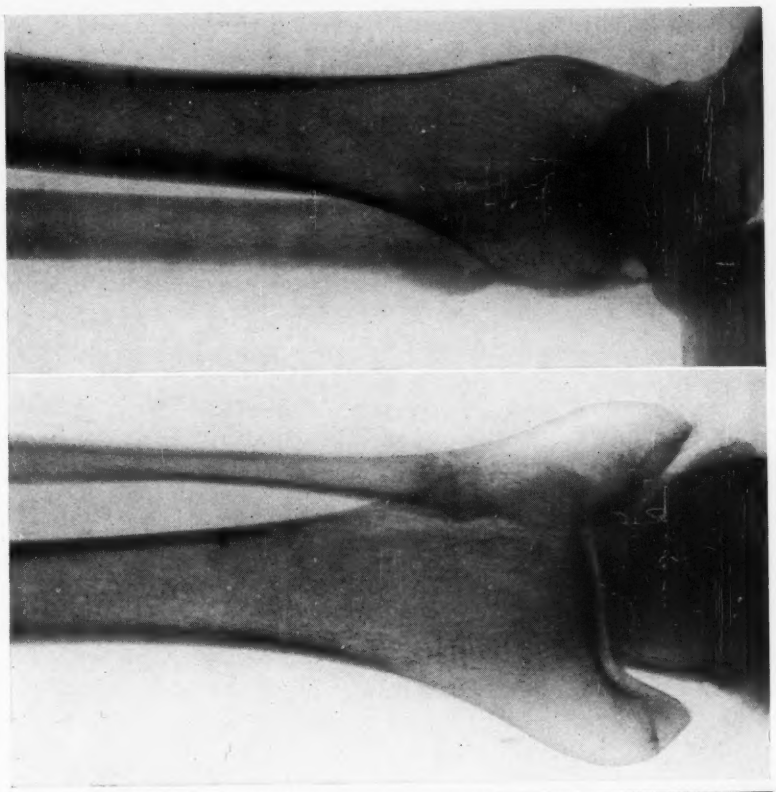

FIG. 43.—*Case* 1. Radiographs taken eight weeks after those in *Fig.* 42.

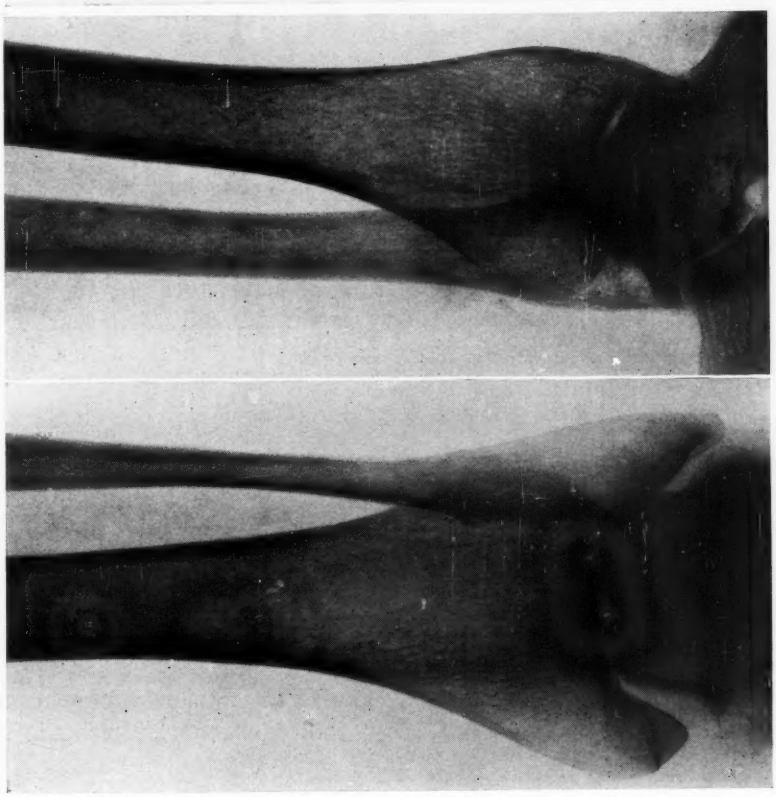

FIG. 42.—*Case* 1. Radiographs taken six weeks after the onset of symptoms.

On examination localized tenderness and thickening were found on the shaft of the right fibula, three and a quarter inches above the tip of the external malleolus. The circumference of the right calf was half an inch less than that of the left. Springing the fibula towards the tibia did not cause pain, and movements of the ankle and tarsus were of full range and painless. Radiographs (*Fig.* 44) showed, in the situation of the swelling and tenderness, a cuff of callus surrounding an oblique fracture which was only just discernible without the use of a lens; the lower fragment was displaced outwards relative to the upper by about half a millimetre. No treatment was advised except temporary restriction of games. Further radiographs, taken eight weeks after the onset of symptoms, showed organization of the callus (*Fig.* 45). Five and a half weeks later he had recovered, except for the presence of bony thickening. Since, he has had no trouble whatever, and eighteen months after the onset of symptoms he was accepted as an officer cadet at the Royal Air Force College, Cranwell.

DISCUSSION

We are concerned with two patients of quite different type. Both complained of the spontaneous onset of swelling and pain of diffuse distribution in the leg. Both stated emphatically that they had suffered no preceding injury, and neither suspected anything so dramatic as a fracture. In each this condition was found in the lowest third of the fibula, displacement being minimal, or almost minimal. The woman's attention was not at any time attracted to the precise site of the lesion; and the boy too was not conscious of it before the tenderness became localized about ten days after the onset.

In the case of the boy the absence of any preceding history of injury should perhaps be accepted with reserve, because such an individual is apt to forget injuries. He had not, however, played vigorous games during the four or five weeks prior to the onset of symptoms, on account of the school winter holidays, so that an unnoticed injury seems improbable. The fracture could scarcely have been caused by the blow sustained three weeks after the onset of symptoms, because localizing signs had already been present for about eleven days, and because the radiological characteristics shown in *Fig.* 44 are not those of a fracture of only two weeks' standing.

The writer has been unable to find any reference in the literature to fracture of the seemingly healthy fibula in its lowest third without any history of injury.

In 1910, Hopfengärtner[1] described fractures of the uppermost third of the fibula, four fingers' breadth below the head, without apparent injury. His 17 patients were infantrymen, aged between 19 and 22, in their first year of service; one of them broke each of his fibulæ on separate occasions, so that there were 18 cases. In 12 cases pain started during or after jumping; in 2 while running, a stone being stepped on; in 1 while marching; in 1 while kneeling; and in 1 while resting: no account is given of the remaining case. In spite of pain the patients were able to continue duty for a few days, after which soft-tissue swelling and localized fibular tenderness were found. In 11 cases X-ray examination failed to reveal bony abnormality till a later stage. Hopfengärtner ascribed those of his cases which became manifest during jumping to violent supination of the foot in association with a longitudinal shock to the leg and possibly avulsion of muscles. Others he compared with spontaneous fractures of the thigh, but unfortunately the work to which he referred in this connection could not be found in any available library. Thöle,[5] writing three years later, ascribed the fibular fracture to muscular action. Köhler,[2] whose book yielded these rather obscure references, uses the

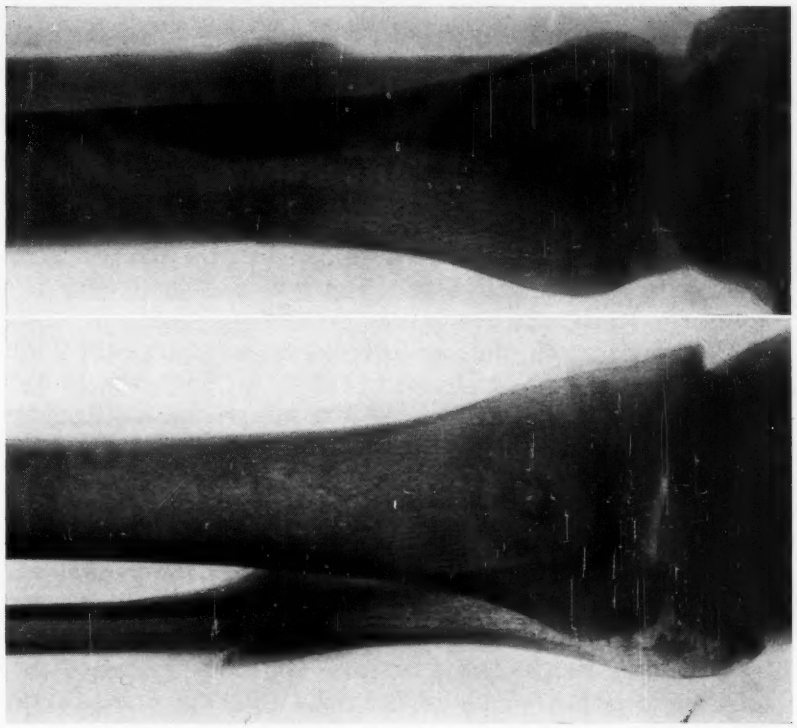

FIG. 45.—*Case* 2. Radiographs taken three weeks after those in *Fig.* 44.

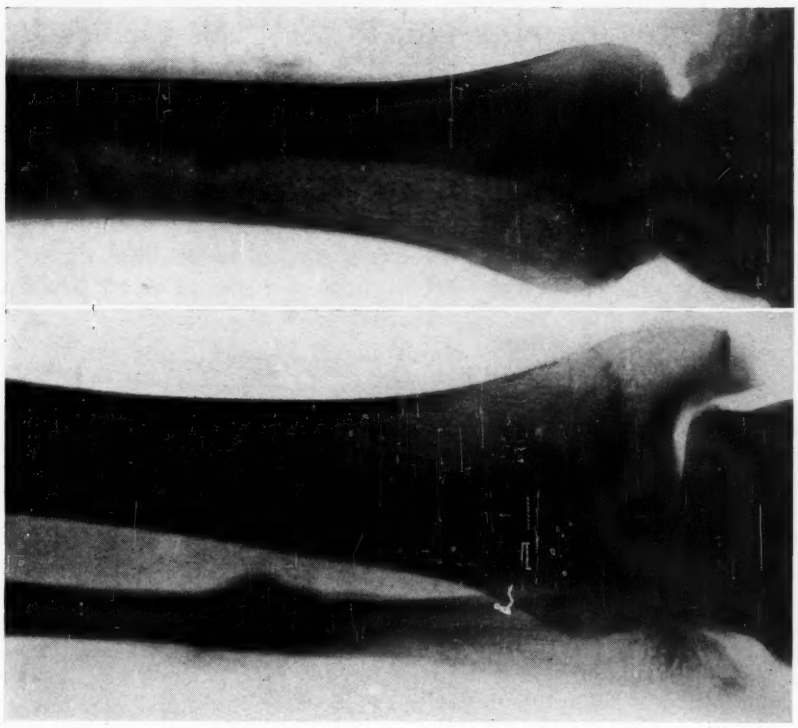

FIG. 44.—*Case* 2. Radiographs taken five weeks after the onset of symptoms.

term " recruit's disease " for the condition described by Hopfengärtner. His statement that an early radiograph may reveal no abnormality is reiterated by Köhler, who, if he is not simply quoting, therefore implies that the observation was not dependent merely upon the less effective radiography of 1907.

In 1938, Reischauer,[4] writing of military cases of overstrain troubles in bone (callus formation, with or without obvious fracture), with special reference to the metatarsal bones and the tibia, mentioned, in passing, such conditions in the fibula as well as the femur, os pubis and os calcis.

The present writer suggests that the cases described may be analogous to those of march fracture of a metatarsal bone. The following characteristics of march fracture come to mind : the affection of the shaft of a long bone ; the onset without violence ; the association with muscular over-use in some instances ; the absence of any audible snap at the time of fracture, and of any suspicion, by the patient, of bony injury ; the diffuse œdema ; the diffuse pain, with little tendency for the patient to locate the site of the injury ; the obliquity of the fracture ; the minimal displacement in most instances ; the liberal formation of callus. It is obvious that some of these characteristics must be common to many subperiosteal fractures which are not immobilized. Nevertheless the analogy is striking, and it may be that when we know the cause of march fracture we shall know the cause of these seemingly spontaneous fractures of the fibula, or vice versa. The same may be true of the military cases of fracture and callus formation without acute injury described by Continental writers (Hopfengärtner, Thöle, Ollonqvist,[3] Reischauer).

One other group of cases is brought to mind—those of spiral fracture of the tibia from relatively trivial rotation strain in children. Such fractures, which are often overlooked, differ somewhat in their clinical behaviour from those here described, but many of the differences might be explained by the greater functional importance of the tibia. There seems to be one respect in which these tibial fractures in children differ fundamentally from the fibular fractures described in this paper : it is nearly always possible, in the writer's experience, to obtain a history of some injury, however trivial.

Whereas two cases provide ground for speculation, conclusions are not warranted by so small a number. This note is written in the hope that any similar cases will be reported, because the establishment of a clinical entity would not only be a matter of academic interest but would lead to the recognition of a condition which is very readily overlooked.

SUMMARY

1. Two cases are reported of subperiosteal fracture of the shaft of the seemingly normal fibula in its lowest third without any history of injury.

2. The characteristics of the condition are discussed, and certain resemblances to march fracture of a metatarsal bone are noted.

3. The misleading nature of the symptoms is recorded.

4. By comparison with a like condition of the uppermost third of the fibula, previously reported, it is thought that early radiographs might fail to reveal the fracture.

5. Mention is made of the desirability of recording such further cases as may be found.

REFERENCES

[1] HOPFENGÄRTNER, "Zur Entstehung von Wadenbeinbrüchen", *Deut. milit. Zeits.*, 1907, **36**, 100.

[2] KÖHLER, ALBAN, *Röntgenology : the Borderlands of the Normal and Early Pathological in the Skiagram*, 1928, 141. (Also 2nd English ed., 1935, 158.) London.

[3] OLLONQVIST, L. J., "Ueber Callusbildungen am Schienbein ohne Knochenbruch", *Arch. f. klin. Chir.*, 1931, **166**, 412.

[4] REISCHAUER, F., "Ermüdungs- und Uebernutzungserscheinungen am Knochen", *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1938, **58**, 343.

[5] THÖLE, "Die Entstehung der typischen Wadenbeinbrüche der Infanteristen", *Deut. milit. Zeits.*, 1910, **39**, 318.

DISLOCATIONS AND FRACTURE-DISLOCATIONS OF THE TALUS

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THE case reported is an interesting one of fracture-dislocation of the talus, which, from its associated fractures and subsequent course, provides an inviting opportunity for commentary on a rare condition. The first case of complete dislocation of the talus was reported in 1803 by Boyer, the term 'double luxation' being applied to it, owing to the separation of both talo-crural and talo-tarsal joints. In fact three joints are involved, the talo-crural, talo-navicular, and talo-calcaneal, and to keep our ideas clear on the subject it is best to keep this in mind. Rognetta in 1833 and again in 1843 published the first full paper on the subject, together with reports of experiments on the cadaver, but the most complete surveys of the condition are the articles by Schmitt, of Leipzig, and Baudet, both published in 1914.

Statistics.—In 1914 Schmitt collected 95 cases, since when, including the present case, 20 more cases have been traced in the literature. The incidence is highest in young adult males. In children the leg breaks before the necessary force to dislocate the talus is developed, and in the old the calcaneus collapses. A fall on to the feet is the most common accident causing the condition, and the height necessary to produce the lesion varies from 6 ft. to 20 ft. in recorded cases. In the present case the lowest height of 18 in. is recorded. Bilateral cases have been recorded twice in the literature.

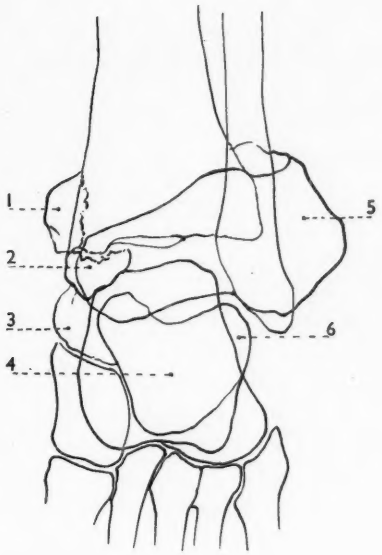
CASE REPORT

HISTORY.—Mrs. J. G., aged 52, weight 11 st. 7 lb., was admitted to hospital on Feb. 2, 1939, at 3.35 p.m. She gave a history of standing with the left foot on a chair while she put the right foot on a table. As she transferred her weight to the table, a leg of the table broke, and she fell, landing heavily on the left ankle, which slipped off the chair. She was unable to give any more accurate description of the position of the foot as "everything happened so quickly". Her ankle was deformed and bleeding and she came to the hospital at once.

ON EXAMINATION.—The patient was not badly shocked, nor was the ankle excessively painful. The foot was held in slight plantar flexion, and slight inversion. There was bruising and broadening of the ankle, with shortening of the distance between the malleoli and the heel. A wound 1½ in. in length running downwards and inwards was present over the apex of the mass, and through it could be seen the articular surface of the talus.

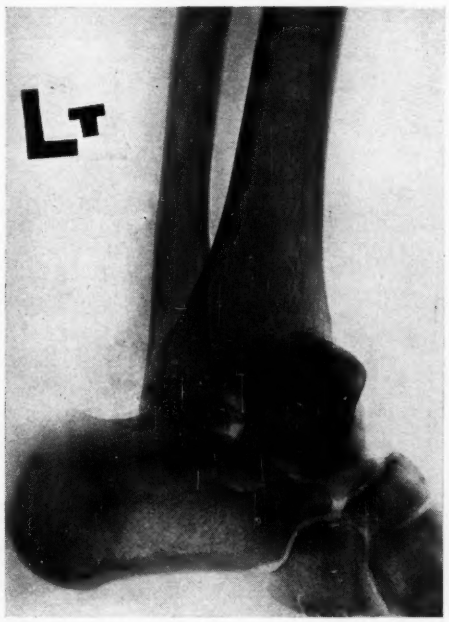
Palpation showed the body of the talus lying transversely across the ankle. All movements at the ankle were extremely painful, and though they could be produced passively to a slight extent, only a small degree of plantar flexion could be produced voluntarily. The circulation in the skin, which was tensely drawn over the displaced talus, was obviously poor. That in the toes was good, and there was no evidence of a nerve lesion.

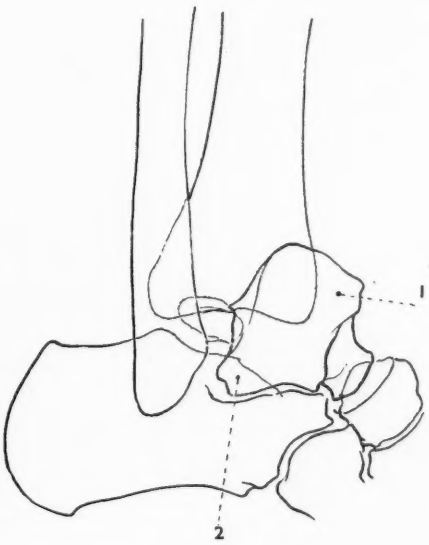
Radiographs taken immediately showed the condition seen in *Figs.* 46, 47, which are explained by the accompanying diagrams. There was a complete dislocation of the talus, so that it lay anteriorly in front of the ankle, with its long axis at right angles to the normal, and its body lying laterally and turned 90° from the usual plane of the transverse



A B

FIG. 46.—A, Antero-posterior radiograph showing anterior and lateral dislocation of the talus before reduction. B, Key diagram: 1, Medial malleollus, fractured and displaced; 2, Medial surface of talus torn out by posterior talotibial ligament; 3, Tuberosity of navicular; 4, Shadow of calcaneal body; 5, Body of talus, articular surface; 6 Trochlear process of calcaneus.





A B

FIG. 47.—A, Lateral radiograph before reduction. B, Key diagram: 1, Body of talus; 2, Lateral process of talus in calcaneal sulcus.

axis. The articular surface thus looked forwards, while the lateral process of the talus rested in the calcaneal sulcus. In addition to this, the medial malleolus was fractured and pushed up on the medial aspect of the tibia, and there was an avulsion fracture of the medial aspect of the talus, corresponding to the attachment of the posterior talo-tibial ligament. The neck of the talus appeared lengthened, but because of its apparent continuity, and the position of the head of the talus, it was not realized that it was fractured till operation. A complete dislocation at all three joints was thus present, talo-crural, talo-calcaneal, and talo-navicular.

OPERATION.—Operative reduction was decided upon, and was commenced three hours after admission. Under local anæsthesia the wound was cleaned, the edge excised, and the distal part of the dorsalis pedis artery tied with silk. The proximal end was not seen. There was no débris in the wound, which was obviously due to bursting of the skin from pressure, but the edges were very bruised. The enlargement of the wound by excision showed the body of the talus to be quite unattached, and the neck of the talus fractured. The body of the bone was turned in all directions to make certain of this, though it was not removed as the wound was not large enough.

FIG. 48.—Lateral radiograph four weeks after reduction, showing the increased density of the upper portion of the body of the talus.

A Kirschner wire was then run through the calcaneus, and the leg was put up on a Böhler reduction frame. Proceedings became painful at this point, and the patient was given a light gas-oxygen-ether anæsthesia. Traction was now applied, but in spite of an increased space opening up between the tibia and the calcaneus it was found very difficult to restore the bone to its original position, as its many processes caught in the gap between the medial malleolus and the neck of the talus, and the slippery surface of the bone was very difficult to control. Eventually, by the use of a flat lever, the bone slipped back into position. There could be no doubt of its position, and the wound was closed without a control radiograph, and the limb plastered from the knee down to the toes. The Kirschner wire was removed and a window cut over the wound. The patient was returned to the ward, the limb elevated on a Braun's splint, the dressings removed from the wound, and a radiant heat lamp placed near it. Control radiographs taken showed perfect reduction.

PROGRESS.—

Feb. 3, 1939. There was moderate swelling of the wound, and there was a sero-sanguineous discharge on the surface, which was still moist. The upper end of the wound was discoloured and blistered, and it was feared it would slough. There was little pain and no temperature.

Feb. 4. More pain in the wound. It was now obviously pulsating over a small area passing across the centre of the wound. This was regarded as a pulsating hæmatoma, due to hæmorrhage from the proximal end of the dorsalis pedis artery which was not seen at the operation, but presumably started to bleed after the relief of pressure given by the reduction of the dislocation.

Feb. 6. The wound was dry, and the pulsation less. From now on the wound healed satisfactorily.

Feb. 20. Fortnightly control radiographs were taken, the limb being removed from the plaster to facilitate comparison of bony densities. Up till this date it had been retained in a complete plaster with window, but from now on a gutter splint only was used. On this date there was no demonstrable change in the density of the bone, though some early callus was visible around the fracture of the neck. Clinically the joint was still swollen, and all movements grossly limited.

March 6. Further X-ray examination. This showed an increase in the density of the body of the talus, particularly marked in the upper half (*Fig.* 48). From this date on, free movements and exercises of the ankle were encouraged, though weight-bearing was not permitted. As a result of this there was less decalcification seen in the other bones than might have been expected.

March 19. Radiography shows some decrease in density of the upper portion of the talus.

April 2. The ankle now showed marked limitation of all movements, but was almost normal in size, and all movements were strong and painless. The radiograph showed a patchy absorption of the density, with some small circular islands of increased density persisting.

April 16. The ankle now showed most marked limitation of dorsiflexion, and the other movements of the ankle were just a little short of complete. The X-ray now showed a complete disappearance of the density of the bone, which now appeared to be as dense as the other bones of the tarsus. The patient was encouraged to get up, and at the end of the next fortnight she could walk firmly and quickly. There was no pain in the ankle on walking, but there was some aching at night.

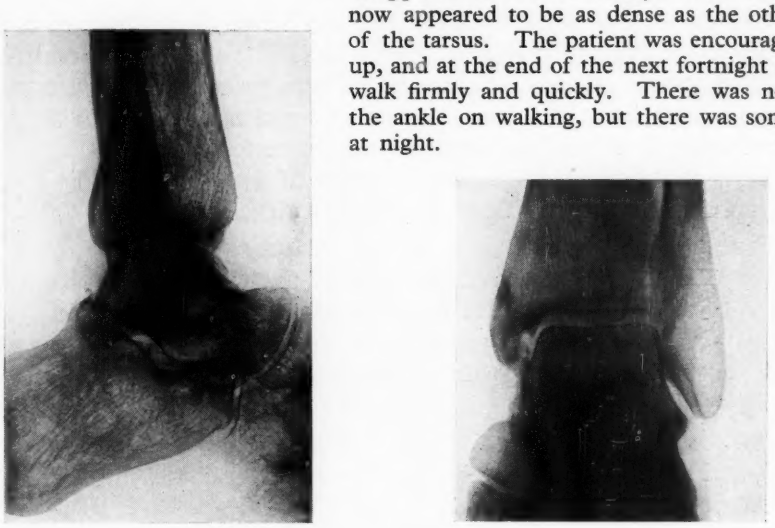


FIG. 49.—Final radiographs, twelve weeks after the accident. Note loss of the patchiness of the bone, and normal appearance of it, and the joints associated with it. The increased density apparent in the lateral view is due to the shadow of the fibula, and is absent in the antero-posterior view.

April 29. Twelfth week. The X-ray appearances are those shown in *Fig.* 49, which do not differ from those of the previous fortnight. Patient discharged. No complaints about ankle. Movements all painless, no crepitus in the joints, all movements a little limited compared to the normal foot by approximately 15 per cent.

October.—Six months later the patient was getting about normally on the foot, and had no complaints. Radiography revealed normal joint surfaces and normal bony density. The ankle was $\frac{1}{2}$ in. larger in diameter than the normal ankle. Movements were limited in all directions by 10 per cent. Inversion and eversion of the heel were possible.

DISCUSSION

The predisposition of the talus to dislocations arises from the fact that it is the only bone in the body without muscular attachment and that three-fifths of its surface is articular. The strength of the talo-crural joint rests on the depth of the tibio-fibular mortice, the talo-tibial ligaments, and the overlying support rendered by the deltoid and lateral malleolar ligaments. The strength of the talo-tarsal articulation rests on anatomical considerations, the slope of the posterior talo-calcaneal joint throwing the head of the talus into the angle made by the short plantar ligament and the navicular. From this it must be noted that there is a weakness of support anteriorly and posteriorly, corresponding to the plane

of the greatest freedom of movement. It is, consequently, in either of these directions that dislocation without fracture of the malleoli occurs.

The weak area of the talus corresponds to the neck, where the sulcus of the talus reduces the thickness of the bone very considerably. It is important to remember that the bone has three axes—a long axis corresponding to the centre line of the neck; a vertical axis, meeting this at an angle equal to that of the neck; and a transverse axis lying in the frontal plane, across the greatest width of the bone. The rotations of the bone in dislocation, always difficult to follow, can only be expressed in terms of these axes.

Blood-supply.—Considerations of the blood-supply, up to the present, have been dominated by the idea that this came only from below, but recent injection experiments have shown that almost all the arteries of the region play a part. The generous supply from all the vessels is important in considering the chances of viability of the bone following dislocation, and many will be surprised how great the chance of survival is, even following complete dislocation. At this point we may draw attention to the near relationship of the dorsalis pedis artery, which may be ruptured or pressed upon in anterior dislocations.

THE CLASSIFICATION OF DISLOCATIONS AND FRACTURE-DISLOCATIONS

The talus takes part in three joints—talo-crural, talo-calcaneal, and talo-navicular. Dislocation is therefore possible at any one joint alone, or in combination, and to these may be added a variety of fractures, so that the number of possible combinations is very high. It is proposed to classify the lesions as primary, secondary, and tertiary, according to the number of the joints involved, the tertiary lesion corresponding to the 'double luxation'.

Primary: Dislocations of the talo-crural joint.
Secondary: Dislocations at the talo-calcaneal and talo-navicular joints:
1. With fractures of the calcaneus.
2. Subastragaloid (subtaloid) dislocations.
Dislocations at the talo-calcaneal and talo-crural joints.
(These cases are necessarily associated with fracture of the neck of the talus, leaving the talo-navicular joint in position. This is the *incomplete* variety of fracture-dislocation of the talus.)
Tertiary: Dislocation at all three joints.
This is the *complete* variety of dislocation or fracture-dislocation.

Primary Dislocations and Fracture-dislocations.—With these this article does not concern itself, except to mention that they may occur without fracture of the tibio-fibular mortice (Alldredge, North).

Secondary Dislocations.—

1. With fracture of the calcaneus. Here both talo-calcaneal joints are destroyed by crushing and the head of the talus dislocated upwards by rotation.

2. Subtaloid (subastragaloid dislocation). Here the talus remains fixed in the tibio-fibular mortice and the foot is torn away from it.

3. With fracture of the neck of the talus. In these cases the talo-navicular joint remains intact. This is not uncommon owing to the strength of the talo-calcaneal interrosseous ligament, the neck of the talus fracturing just behind it. This is the incomplete variety of fracture-dislocation, or dislocation of the body only.

It may be :—

1. Anterior : (*a*) medial, (*b*) lateral, (*c*) midline.
2. Posterior : (*a*) medial, (*b*) lateral, (*c*) midline.
3. Medial.
4. Lateral.

The second columns refer to the side to which the body is displaced. Rotary displacements in any but the vertical plane are neglected, as they are multiple and complex, and do not influence the discussion.

Tertiary Dislocations and Fracture-dislocations.—These are the rarest and most interesting varieties. The whole bone may be displaced intact, or the neck may be fractured, and if the latter occurs it is debatable whether the fracture of the neck takes place before the dislocation or afterwards. This point arises in the consideration of the recorded case.

The displacements may be :—

1. Anterior : (*a*) lateral, (*b*) medial.
2. Vertical : (*a*) head above, (*b*) head below.
3. Reversed.

It is with this group that this article is concerned. Numerous fractures may be associated with these dislocations and fall into the following groups : fractures of the neck ; fissure fractures of the body ; crushing of the body with fragmentation ; fractures of the posterior process ; and traction fractures of the ligamentous insertions. The various rotations of the bone which may be associated with dislocation are interesting, not only on account of their variety but on account of the mechanism. Rotation may occur in all three axes. The most interesting is the 180° rotation in the long axis, which produces the ' reverse ' dislocation with the ankle of the neck open upward. Rotation in the transverse axis occurs in almost all cases, and rotation in the vertical axis occurs to 90° in the common antero-medial and antero-lateral dislocations. In most cases there is a combination of displacements in all three axes. The factors governing the rotation appear to be : the deforming force ; the elasticity of the skin ; the ligaments which remain unbroken, and the sequence of those ruptured ; and lastly, the attempts of the patient to walk, or of helpers to reduce the dislocation.

Incidence.—Owing to incomplete descriptions of the position of the bone and the absence of X-ray control in earlier cases, the frequency of individual lesions is difficult to determine. The facts standing out, however, are that postero-medial and antero-lateral dislocations are the most frequent, suggesting a definite mechanism. The less common lesions are possibly further accidental displacements of the more frequently found positions.

Old Terminology	*Schmitt's Series*	*Present Series*	*New Terminology*
To front and outward	33	5	Anterior and lateral
To front and inward	9	2	Anterior and medial
Posterior	7	2	Posterior and lateral
		9	Posterior and medial
Inwards	19		Medial
Outwards	6	1	Lateral
Forwards	10	1	Anterior midline

Absence of accurate records prevents the regrouping of the ' Inwards ' and ' Forwards ' cases.

SYMPTOMS AND DIAGNOSIS

A history of a fall from a height on to the foot is usually given, but rarely other types of accident may be responsible, such as weights falling on the foot or leg. The description of the accident by the patient is usually poor, as the injury occurs so suddenly, but now and then from the peculiar circumstances of the case it may be of great help in deducing the mechanism, and should be gone into as fully as possible.

The most obvious points are the occurrence of gross swelling and œdema of the ankle, with severe bruising. This is rapid in onset and may obscure the picture and prevent the palpation of the displaced body of the talus, which can usually be identified in its new subcutaneous position on account of the characteristic form of the saddle-shaped articular area. Forty-four per cent of cases are compound, and in them the talus can often be seen in the wound. When the condition is not compound the skin is very tense over the displaced bone, depending on its size and position, and may show circulatory changes or the stages of gangrene. Crepitus is usually absent.

Anterior Dislocations.—The body of the talus lying under the skin on the dorsum of the foot makes a very obvious swelling anterior to the medial or lateral malleolus. The skin is stretched tightly over it, as there is less slack tissue than in posterior dislocations, and is frequently ruptured. The distance between the malleoli and the heel is shortened so that the foot appears increased in length and the ankle appears broader, which is increased by the bleeding into the tissues. The calcaneus is a little less prominent than usual, and the foot is held in slight plantar flexion, with adduction in the case of antero-lateral dislocations, and abduction in the case of antero-medial dislocations. All movements of the ankle are painful, and increased lateral mobility of the heel may be detected. Dorsiflexion is impossible, but plantar flexion can be increased voluntarily. The dorsalis pedis artery is liable to rupture, and may give rise to a pulsating hæmatoma.

Posterior Dislocations.—The foot is held in plantar flexion, and in posterior and medial dislocations there is slight adduction of the foot. The body of the bone is readily palpable in the hollow of the lateral or medial side of the tendo calcaneus, where it usually forms a visible swelling. Rupture of the skin is less common. Failure to diagnose these cases in the early stages, without X-ray aid, was common, as the position of the body does not interfere with the tibia settling down on the calcaneus. The toes are flexed, and there is pain on movement of the great toe and the other toes owing to the pressure on the tendons of the flexor hallucis longus and the flexor digitorum longus. There may be pressure on the posterior tibial nerve, with pain and paræsthesia, or division and paralysis. The posterior tibial artery may also be injured.

In the very rare posterior and midline dislocation a gap is left between the anterior edge of the tibia and the neck of the talus, which may be readily detected.

In all cases the diagnosis can only be accurately completed by radiographs, and it is only on the X-ray appearances that the fracture-dislocation or dislocation should be classified.

THE MECHANISM OF DISLOCATION AND FRACTURE-DISLOCATION

This has always been an interesting field for speculation, and consideration of the following subjects has shed much light on the condition. (1) The accident itself;

(2) Experiments on the cadaver; (3) The findings at operative reduction; (4) The X-ray findings; (5) A study of the bony and ligamentous architecture of the ankle.

Space does not permit a full consideration of these interesting researches, so we must confine ourselves to the description of the mechanism arrived at by consideration of these facts, and the points of interest of the case in hand.

The Mechanism of Anterior Dislocations.—It is agreed, with the one dissentient voice of Henke and an admission of Schmitt, that anterior dislocations take place in plantar flexion. It is, however, possible to conceive a subastragaloid dislocation in dorsiflexion followed by a blow on the front of the leg which causes the tibia and fibula to slip back, and on the elasticity of the tissue attempting to restore the normal position the talus becoming pushed forward. Admitting then that this very rare combination of forces may cause anterior dislocation, we must insist that 95 per cent are caused by plantar flexion. Again we have to consider medial and lateral dislocations and their relation to abduction and adduction of the foot. The common displacement is a lateral one, the mechanism being a fall on the foot in acute plantar flexion and inversion, and the talus being twisted so that its body lies in front of the fibula, while the head lies in the navicular fossa, but at right angles to its usual position. Anterior and lateral dislocations occur more frequently, as inversion occurs more readily, due to the absence of lateral support provided by the fibula, and the obliquity of the tarsus and metatarsus tends to deflect a plantar-flexed foot in this direction. Anterior and medial dislocation is produced by a fall on the plantar-flexed and everted (or abducted) foot, and forms only 30 per cent of anterior dislocations.

The Problem as to which Joint is First Dislocated.—There are only three possibilities: dislocation occurs at the talo-crural joint first, or at the talo-tarsal joint first, or it occurs at both joints simultaneously. This latter possibility cannot be ruled out, but is mechanically unlikely. Henke champions the belief that dislocation at the talo-crural joint occurs first; against this are ranged Stetter, Schmitt, Schlatter, and a large number of others, who all base their arguments on the fact that the interosseous talo-calcaneal ligament is the strongest ligament which has to be ruptured to produce the lesion. On this argument alone they deduce that the ankle must be intact to allow the development of sufficient leverage to rupture the ligament. Against their arguments we should like to advance the following points: It has been shown already that dislocation at the ankle can occur without malleolar fracture, and this is the common condition in subastragaloid dislocations, which indicates that to the appropriate force each ligament offers an equal amount of resistance, so that the talo-calcaneal ligament is not necessarily the stronger. If subastragaloid dislocation occurred first the foot would readily pass into complete inversion, and the force dislocating the ankle would be spent. A further point is that the greater the plantar flexion of the foot, the less force is developed from inversion and eversion, and the less strain imposed on the talo-calcaneal articulations. In plantar flexion the narrow portion of the talus can be easily dislocated, and if the subastragaloid dislocation occurs first the talus will readily pass into the neutral position, rendering dislocation difficult. All these points induce me to favour dislocation occurring at the talo-crural joint first, and to this may be added some support from consideration of the present case.

In this case the fracture of the medial malleolus was produced by the force of a fall on the inverted foot, which would jam the talus firmly against the inside

of the malleolus. Malleolar fracture is a common finding in all anterior and lateral dislocations. In this case, however, the posterior talo-tibial ligament has been torn out from its attachments to the medial surface of the talus, and has taken a small flake of bone with it. It is possible, but unlikely, that this would occur if the malleolus was fractured first. The ligament would then rather drag the fractured malleolus with it, than pull out from the talus. In this case the malleolus is pushed high up on the medial side of the tibia. This seems to be a point strongly in favour of dislocation having occurred at the ankle first. This is further borne out by the presence of the fracture of the neck of the talus. In spite of this, the bone was displaced as a whole, the talo-calcaneal ligament being incompletely divided. This must have occurred before fracture, or the head would have remained in situ, and the whole of the bone must have been displaced before the fracture occurred, for the normal relationship of head and body to remain. This could only occur if we had a complete dislocation at the ankle without malleolar fracture, accompanied by a ligament strain fracture of the medial aspect of the talus, where the talo-tibial ligament is strongly attached. The neck of the bone would then lie unevenly supported across the sinus tarsi, and the short plantar ligament. If the medial malleolus impinged on top of this, as it would, it is possible to imagine it dislocating the talus, fracturing the neck of the bone, and finally the malleolus itself fracturing and being pushed up the medial surface of the tibia. This force would also rupture the skin, which would be stretched across the bones between them and the ground at that point, if this idea is true. Such appears to me to be the likely explanation of the mechanism in this case. The proof is not, however, absolute, as the alternative theory that the subtaloid dislocation occurred first, and then the weight of the body on the talus broke its neck, and pushed the malleolus up, and finally dislocated it with avulsion of the posterior talo-tibial ligament from the side of the talus, can certainly be held, but does not appear to be so satisfactory an explanation. It is thus impossible to be dogmatic about it, and the final possibility that in some cases the talo-crural joint goes first, and in some the talo-tarsal joints first, must conclude this summary of opinions.

TREATMENT

This is influenced much more by whether the case is seen early or late, than by whether it is compound, or a fracture-dislocation, as opposed to a dislocation. That cases are frequently compound has been remarked upon, and we must once again emphasize the fact that it is necessary to treat a case in which the skin is tightly drawn across the separated body as early as is possible, to avoid pressure gangrene of the skin. Where the skin is loose, it is possible to temporize, but if it is tense, then every minute counts. Compound fractures are treated on the usual principles, as set out briefly in the case described, where excision of the skin, accurate suturing, the avoidance of any buried foreign body, and open-air treatment of the wound led to a successful result in a not altogether favourable case.

The possibilities of treatment in cases seen immediately are :—

1. Immediate reduction :
   - *a.* Manipulative.
   - *b.* Manipulative aided by skeletal traction.
   - *c.* Operative.
2. Removal of the body of the talus.
3. Complete removal of the talus.

In cases seen later, the talus is probably established as a sequestrum in the wound, if it has been compound, and may be removed to improve drainage. If, however, it is not involved in the wound it must be left till this has healed, and treated along the lines of the non-compound cases. In these there is as a rule only a choice of the second and third methods, and this will be enlarged upon under these headings. It is difficult to say how long a displaced talus may remain so, and be viable after reduction. Cases reported seem to show that after 24 hours' displacement they disintegrate later, even if reduced, and almost certainly after 48 hours.

Reduction.—The ease of reduction varies with the type of displacement, as is to be expected. In anterior and medial dislocations the short medial malleolus does not interfere with reduction to the extent that the fibular malleolus does, and as the body is not so far displaced from the mortice as in other cases, reduction occurs readily by manipulation in all cases. This is not so with the antero-lateral dislocations, which, as in our case, give rise to much unexpected difficulty, whether the neck of the bone is fractured or not. The deep bony margin of the fibula, the fact that the body is more completely dislocated, and the calcaneus and the tibia are more closely approximated, and require great force to separate them sufficiently to allow the body to slide in, all obstruct reduction, and most of the reported cases have gone on to open operation. Skeletal traction is a definite aid, as it gives a controlled extension of the space between the calcaneus and the talus. Owing to the irregular nature of the fractured talus, a number of processes jut out and render return of the body, even into an adequate space, a little difficult, unless its movements are controlled, and a lever in the open wound seems to serve best as a guide. It need scarcely be emphasized that no hesitation about opening the skin should be made following failure to reduce the dislocation by manipulation.

Removal of the Body of the Talus.—This has been the most frequently tried line of treatment, owing to fear of necrosis of a bone completely divorced from its attachments, and owing to a number of cases being seen later, when the treatment was more of an orthopædic nature. The fear of necrosis of the talus is quite ungrounded, and in 20 recent cases which have been reported, this stands out as an important fact, which in the view of the modern ideas of avascular necrosis of bone must be emphasized strongly. Four of the series were old cases, and so treated by removal of the body. Of the 16 immediate cases, 3 were treated by talectomy (astragalectomy), one with a very bad result, the others with a fair result. In the remaining 13 cases the bone was replaced, in 2 cases after its complete removal and washing in saline (Ollerenshaw, Simon), and in all but one of these cases the result has been satisfactory. In this one case the reduction took place four days after the accident, which is sufficient explanation. Disintegration took place after an early period of normalcy and ere this some evidence to suggest that it was due to mild sepsis. I think this only serves to emphasize the almost uniformly good results which have occurred after early reduction. Admittedly doctors would be more inclined to write up successful cases than unsuccessful ones, but this cannot affect such overwhelming figures. Another important point is that when once the case has started to do well, it continues to do well, and reports at intervals of years show the talus to be still in good condition.

The importance of this observation and its relation to the theories of avascular necrosis of bone is immense. It appears that the present ideas do not satisfactorily

explain all cases. In certain conditions such as the inflammatory lesions of bone, and the osteochondritides, the theory fits in with the observed facts, though not yet proved up to the hilt. In this case, as has apparently occurred in all the other recorded cases, the bone first increases in density or radio-opacity, as is well shown in the radiograph four weeks after the accident (*Fig.* 48). Following this is a period in which the radio-opacity becomes less, and this takes place in a patchy manner, shown in the film at the sixth week. The circular or irregularly oval patches of increased density which remain are localized by the antero-posterior and lateral radiographs to the interior of the bone. No definite change can in fact be seen in the bony lamellæ, and in the tenth week the bone was restored to normal with a density equal to the other bones of the tarsus. Here in the general decalcification of disuse the talus seems to have taken an equal part. It is suggested that these changes of density are not therefore due to the talus remaining of normal density while the rest of the foot, which has a good blood-supply, undergoes decalcification, but to some change in the interior of the bone, such as an increase of radio impermeability due to the breakdown of fats in the cancellous tissue from poor blood-supply. In other words, the ' avascular necrosis ' is in the cancellous bone spaces and not in the bone itself.

In the case recorded one need not emphasize that every care was taken to be certain that the body of the talus had no connexion with any surrounding tissues. One must presume that a new circulation was established in the bone from the granulation tissue in the fractured neck, and possibly while this was developing the bone obtained sufficient nourishment from surrounding tissue fluids. In our case we did not allow weight-bearing till the appearance of the bone was normal. Others have not waited for this, and one successful case is reported in which the patient was got up on the fifth day. With further observations the period of immobilization could be better determined, and we should expect it to be a month to six weeks, and it would appear advantageous to leave the leg free for exercises, and merely avoid weight-bearing, after the first three weeks.

The results in cases in which the bone has remained dislocated for more than forty-eight hours before it was reduced are bad, and warrant early removal of the fragment or the whole bone. After forty-eight hours' displacement the bone undergoes degeneration. This degeneration is possibly a true avascular necrosis. There is alteration in the density of the bone as outlined, but the bone begins to lose its sharp outline, and later fragmentation with complete destruction of the joints sets in. For this there is no treatment but a radical removal of the bone and an attempt to get a rigid stable foot after all the fragments of the talus have been removed. In the cases reported the results of immediate removal of the body of the talus have been unsatisfactory, though it is hard to see why this is so when talectomy for other conditions has been satisfactory. With an insufficient number of cases to decide upon, and in the present state of knowledge, one would be tempted to try the return of the dislocated bone, particularly in the less complete lesions, in all cases under a week's duration of unreduced dislocation. If it became apparent that the bone was degenerating, then recourse would be had to early talectomy, or partial talectomy if the neck and head of the bone were viable.

Complete Removal of the Talus.—Once more we must emphasize the fact that complete separation of the talus from all its attachments does not justify removal of the bone if the case is seen early. The point for discussion which one

wishes to raise under this heading is whether in late cases, in which the neck is fractured and the head is viable, it is better to remove the whole bone or the head alone. The argument advanced in support of removing the whole bone is that the tibia is allowed to move farther forward on the calcaneus, and so approaches nearer the centre of the arch of the foot, thus making a more stable articulation. This is, I think, a little meretricious, for the retention of the head of the talus is of paramount importance in the maintenance of the arch of the foot, and so its retention has, perhaps, stronger grounds than its removal. A much more satisfactory result is achieved by freshening the anterior surface of the tibia, just above the articular surface, trimming the neck of the talus so that it comes into apposition at a good angle, and fixing the two together by a bone-peg driven through from the navicular aspect.

SUMMARY

1. A rare case of antero-lateral fracture-dislocation of the talus is reported.

2. An academic discussion of the dislocations and fracture-dislocations of the talus is given, with a suggested classification.

3. The mechanism of dislocation and its problems is discussed.

4. The diagnosis and treatment are discussed.

5. The remarkable vitality of the talus after complete separation of its attachments is emphasized, and mention is made of the importance of this observation in regard to theories of avascular necrosis.

6. A reference list which covers directly and indirectly all the available literature on the subject is appended.

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BIBLIOGRAPHY

BAUDET, " Contribution à l'Etude des Fractures d'Astragale ", *Rev. de Chir.*, 1914–5, **50**, 305. (Full review. History. References. Mainly repetition.)

BORCHARDT, *Chirurgie der unteren Extremitäten*, vol. VI of *Handbuch der praktischen Chirurgie*, 1923, 569.

CONWELL and ALLDREDGE, " Complete Compound Dislocation of the Ankle-joint without Fracture ", *Jour. Amer. Med. Assoc.*, 1937, **108**, 2035.

COURTY and GODART, " Un cas de Fracture transversale du Col de l'Astragale, avec Luxation en arrière du Fragment postérieur ", *Paris méd.*, 1920, **10**, 412.

DAVIS, B. F., " Fracture-dislocation of the Astragalus ", *Surg. Clin. Chicago*, 1919, **3**, 1461.

GIBSON and INKSTER, " Fractures of the Talus ", *Canad. Med. Jour.*, 1934, Oct., 357. (Reports experiments on cadaver.)

HENKE, " Die Luxationen der Fusswurzel ". *Zeits. f. rationelle Medecin*, 1858, **2**, 173.

KILLIAN, " Schwierige Reposition einer Talus-fractur, durch direkte Extension ", *Zentralb. f. Chir.*, 1936, **63**, 18.

MERCER, W., " Fracture-dislocations of the Talus. Two Cases and Mechanism ", *Edin. Med. Jour.*, 1928, **35**, 465.

MITCHELL, " Total Dislocation of the Talus ", *Jour. Bone and Joint Surg.*, 1936, **18**, 212.

MONTGOMERY, " Fractures through the Neck of the Astragalus ", *Ann. of Surg.*, 1917, **65**, 495.

NORTH, " Compound Dislocation of the Talus without Malleolar Fracture ", *Jour. Bone and Joint Surg.*, 1938, **20**, 458. (List of references appended.)

OLLERENSHAW, " Rotation Dislocation of the Astragalus ", *Brit. Med. Jour.*, 1921, Jan., 155. (Report 1 case.)

PETERS, " Zur Behandlung der Talus-Fraktur und Luxation ", *Zentralb. f. Chir.*, 1929, **56**, 1228. (1 case.)

PIREAUX, " Un Cas de Luxation double de l'Astragale ", *Arch. méd. belge.*, 1924, **77**, 963. (1 case.)

ROBINSON, " Fracture Dislocation of the Astragalus ", *Ann. of Surg.*, 1919, **63**, 606. (1 case, mentions 5 others.)

SCHLAGENTWEIT, *Deut. Zeits. f. Chir.*, 1907, **88**, 101. (Reports of cases.)

SCHLATTER, " Zur Kasuistik der Talusluxationen ", *Beitr. z. klin. Chir.*, 1894, **2**, 80.

SCHOSSERER, " Ueber Talus-Luxation ", *Arch. f. klin. Chir.*, 1930, **160**, 767. (Case of bilateral dislocation.)

SCHMITT, " Zur operativen Behandlung der Talus-Luxation ", *Deut. Zeits. f. Chir.*, 1914, **130**. (1 case of bilateral dislocation. Very full article. The basis of most German text-book articles. Full list of earlier references.)

SIMON, " Zur Behandlung von Talus-fraktur und Subluxation ", *Zentralb. f. Chir.*, 1928, **55**, 732. (1 case.)

SNEED, " The Astragalus. Dislocation, Excision, and Replacement ", *Jour. Bone and Joint Surg.*, 1925, **7**, 384. (1 case.)

STEALY, " Fracture of the Astragalus ", *Surg. Gynecol. and Obst.*, 1909, **8**, 36. (1 case. Exhaustive reference lists to that date, containing 256 references.)

STETTER, *Compendium der Lehre von der frischen traumatischen Luxationen*, 4th ed., 1896. Berlin: G. Reimer.

WEITZEL, " Note sur les Luxations formées de l'Astragale s'accompagnant ou non de Lésions malleolaires, et sur le Luxations fragmentaires de cet os ", *Rev. de Chir.*, 1925, **63**, 306.

DELAYED OSSIFICATION OF THE TIBIA IN APPARENT CONGENITAL ABSENCE

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CONGENITAL defects in the long bones of the extremities are of interest both to the surgeon and to the embryologist. As the diagnosis of many of the deformities is verified by, or even based on, radiographic findings, the case reported here presents features sufficiently unusual to warrant description.

CASE REPORT

HISTORY.—On March 13 a first-born male infant was admitted, two hours after birth, to the Royal Hospital for Sick Children, with imperforate anus and deformity of the left leg. There had been an uneventful full-time pregnancy, with normal delivery. The mother and father were healthy, and there was no history of deformities on either side.

ON EXAMINATION.—The perineum appeared broad, but showed no evidence of an anus. The left leg was shorter than the right, and was held flexed at the hip and knee. Half an inch of the shortening was accounted for in the proximal segment of the limb, but the distal segment showed an outward and backward curve, with a dimple on the summit of the curve, and was only two-thirds the length of the corresponding segment of the normal limb. All five digits were present, and the foot showed a mild degree of equino-valgus deformity. A provisional clinical diagnosis of intra-uterine fracture of the tibia and fibula was made.

TREATMENT AND PROGRESS,—

March 13, 1938: Operation, shortly after admission, entailed dissection up towards the concavity of the sacrum, where at the depth of 3 cm. I found a blind-ending rectum. This was brought down, incised, and stitched to the margins of the perineal wound.

FIG. 50.—Radiograph, March 15, 1938. There is no trace of the left tibia: the fibula is thick, bowed, and dislocated to the lateral side of the femur.

FIG. 51.—Radiograph, Oct. 15, 1938. An osseous centre is visible in region of lower third of left tibia. The outline of the shaft does not show up so clearly as in the original plate.

March 14: X-ray examination revealed no trace of the left tibia, the left fibula was thicker than normal and slightly bowed, and the upper end was dislocated to the lateral side of the femur (*Fig.* 50).

Attempts to straighten the leg failed, because of the congenitally short hamstring muscles, but as the foot was relatively normal it was thought worth while to do something further.

FIG. 52.—Shows the X-ray appearance on Feb. 15, 1940. There is an increase in size of the osseous centre in the tibia. The outline of the cartilaginous shaft shows clearly.

March 23: The new anus continued to function in a satisfactory manner, and the child was dismissed—to return when its grip on life was more assured.

May 7: X-ray examination revealed further growth of the left fibula, and also disclosed congenital dislocation of the left hip.

Before attempting to reduce the dislocation of the hip, I decided to lengthen the left leg by impacting the upper end of the fibula between the femoral condyles (Albert's operation). Although unable to correlate my findings on palpation with the X-ray plates, on *May* 29 I explored the region of the knee-joint, and was perturbed to find an apparently normal tibial head, articulating in the usual manner with the femoral condyles. The head appeared to continue down into a short shaft. The head of the fibula articulated with the upper part of the lateral femoral condyle. This connexion was separated, but extension could not bring the fibula down from its abnormal position. The operation was concluded at this point. X-ray examination the following day revealed no trace of a tibia.

June 4: Radiography showed no change in the appearances of the leg, and no further plates were taken until *Oct.* 15. This photograph revealed an osseous centre presumably in the lower third of a left tibia, with the faint outline of a short squat tibial shaft (*Fig.* 51). More recent radiographs have shown an increase in size of this centre of ossification of the tibia, and an increase in length of the presumably cartilaginous shaft. As there has been no increase in the valgus deformity, the tibia is apparently growing at the same rate as the fibula.

Fig. 52 shows the X-ray appearance on *Feb.* 15, 1940. There is an increase in size of the osseous centre in the tibia. The outline of the cartilaginous shaft shows clearly.

DISCUSSION

Congenital Deformities.—The aetiological factors concerned in the production of congenital deformities are as yet obscure, and although many 'explanations' have been advanced, none satisfies.

Dareste (1882) developed the theory of mechanical interference from without; and pressure of the amniotic fluid, amniotic bands, and the umbilical cord, have all been blamed for congenital defects. This theory appears to explain in a satisfactory manner such deformities as intra-uterine amputation, cord constrictions, and varying degrees of arrested development. Unfortunately it cannot explain why the defect is often so regular and bilateral, nor why supernumerary digits occur.

Hoffa excised the scar over the convexity of a leg with congenital absence of one bone, and found "structure compatible with pressure from without". More recently Ollerenshaw examined the bone and skin coverings over a congenital amputation, but found no evidence of scar tissue.

The theory of maternal injury is not satisfactory, as the fœtus is well protected in its amniotic bath. The bones and muscles are well differentiated at the sixth week of fœtal life, and it is difficult to conceive of violence interfering with an individual bone when the fœtus is only about 4 cm. long.

Defects have been found in the spinal cord and cerebrum, corresponding to the site of various limb deformities, but it is impossible to say whether or not the defects in the central nervous system are consequences, rather than causes, of the abnormalities (Schmid, 1902; Walls, 1940).

According to Gegenbaur, the pelvic fin of the Dipnoan fish is equivalent to the human hind limb. The main stem of the fin ray represents the femur, tibia, medial tarsals, and toes; the four accessory rays correspond to the remaining bones. Thus, where one long bone of a pair is absent, and yet all five digits are present, this would be explained by the coalescence of bones (or rays). The pentodactyle limb of tetrapods is differentiated into three regions; in both limbs the endo-skeleton consists of a single proximal element (femur or humerus), two elements (pre- and post-axial) in the middle region, and several elements in the distal region. Although this cheiropterygium resembles the icthyopterygium of Pisces, there is no convincing proof of this derivation (Goodrich).

Virchow (1865) postulated a 'phlogistic' diathesis in which some irritative or inflammatory process acts as a causative factor in producing malformations. More recently Bagg (1929), by submitting female mice to X rays, produced deformities in the limbs, eyes, and kidneys of the progeny. Minute blister blebs form on the primitive limb bud of the young embryo, and the underlying mesenchyme is involved in the nutritional disturbance, causing an upset in the pre-cartilaginous skeleton. The deformity varies according to the extent and severity of the lesion. Deformities ranging from polydactyly and syndactyly to congenital absence of parts was observed. Of the remaining theories, the only one of interest is that which suggests that congenital deformities are due to a primary defect in the blood-supply of the part.

Several authors stress the hereditary tendencies which are shown in some cases. Although interesting, these cases are exceptional.

Murray (1925), Fell (1929), Niven (1933), and others have shown that the form of the cartilaginous model of a long bone is produced from a pattern intrinsic in the element at a very early stage of development. This early form is independent of imposed stresses and strains and of muscle pull, although perfection of the cartilage model cannot be achieved by these intrinsic factors alone. The tibia, for example, is in part moulded by its surrounding muscles. The hereditary form of the bone is maintained from the mesenchymal stage to the vascular bony stage by calcification of the matrix of the senescent cartilage (Leriche and Policard, 1928). Anything which interferes with the orderly progression of cartilage to bone will lead to malformations in varying degrees.

Harris (1933) states that there are certain definite periods in embryonic life peculiarly associated with catastrophic changes in development. Development and growth of the cartilage skeleton occur mainly during the 4th and 5th weeks of embryonic life, and from the 7th to 9th weeks there is widespread calcification of the cartilage of the long bones. During the last eight weeks there is a rapid growth in length of the long bones, as distinct from the increase in size of the epiphysis.

Suppression of mitosis in the cartilage of a long bone at the 5th week of fœtal life may lead to complete failure of development, giving rise to congenital absence of the affected bone. Suppression of mitosis at one end of a bone would lead to partial absence of that bone. These perversions in growth due to interference

with the nutrition of the cartilage may be determined by errors in nutrition, hereditary factors, or by the increased susceptibility of the rapidly growing skeleton to noxious substances.

Deformities of the Lower Limb.—The literature shows that congenital absence of the tibia is an interesting and uncommon deformity. Hoffa (1890), in assessing 9877 cases of congenital deformity, found no examples, but Nuzzi (1920) found records of 81 cases of deficient tibia. The reports stress the association of the defect with other congenital malformations, but I have been unable to find any systematic follow-up of cases exhibiting the lesser degrees of deformity. The diagnosis usually rests on the X-ray findings, and the original plates of the present case present the typical picture of congenital absence of the tibia, as illustrated in several text-books.

Ollerenshaw (1925) reports a case of identical twins, whose deformities were radiologically comparable with the appearances in the present case. In the first child the fibula was half as thick again as a normal fibula, and the upper epiphysis of the tibia was approximately of normal size and showed on the radiograph. Dissection revealed a trace of the tibial diaphysis. All five metatarsals were present, and there was a double hallux. In the second child there was no trace of the tibia on X-ray examination, and all five metatarsals were present; there was no double hallux. Dissection revealed complete absence of the tibia; an interesting point was the presence of a well-developed muscle, which had both origin and insertion into the fibula, and yet which could not possibly have had any function. Both specimens were obtained after amputation. In the same article there is a report of a full-term dead child, which clinically and radiologically is almost identical with the present case when first seen. On dissection of the leg of this dead child, a band of fibrous tissue, resembling the tibia, was found.

Ossification normally begins in the middle of the body of the tibia about the 7th week of fœtal life. In the present case the primary centre for the body appeared radiologically about seven months after birth. Presumably the tibia was developed in cartilage during the 4th and 5th week of fœtal life, but about the 7th week we might postulate some metabolic disturbances, localized to the left tibia. Thus calcification did not occur, although the cartilaginous tibia continued to grow, but with some retardation of growth in length. Shortly after birth no radiological evidence could be obtained of the presence of what was still a purely cartilaginous tibia. But operative exploration did reveal the presence of a tibial head with articular surfaces of approximately normal size and outline. Later, a greatly delayed ossification has taken place in the cartilaginous shaft, and the shadow now shown by the shaft as a whole is presumably due to pre-ossification changes in the rest of the cartilage. Growth in the deformed limb has continued at approximately the same rate as in the normal limb, and growth in the cartilaginous tibia at the same rate as the fibula (there has been no increase in the mild club-foot deformity).

On consulting the available records at the Royal Hospital for Sick Children, I traced several cases of congenital absence of one of the two bones in forearm or leg, but, with one exception, the entire segment (i.e., the corresponding metacarpals or metatarsals and digits) was absent. In the remaining case a diagnosis of congenital absence of the fibula was made on radiological grounds, although all five digits were present. At the age of six, a radiograph revealed faint ossification

at the distal end of the fibula, and at a recent X-ray examination at the age of ten, the outline of the cartilaginous fibula appears to be visible, and the centre at the lower end is more apparent.

CONCLUSIONS

I do not attempt to explain the series of events which has been described, but it would seem possible that further light may be shed on the difficult problem of bone formation by detailed investigation of this type of case.

Early amputation is not infrequently the line of treatment adopted on cases of this type. But I would suggest that too much stress should not be laid on the original radiographic findings, and that amputation should be at any rate delayed, as there may be considerable improvement in the usefulness of the limb.

In the present case, the final decision as to treatment may not be made for several years.

SUMMARY

1. A case of apparent congenital absence of the tibia is described, in which the true condition was one of delayed ossification.

2. A similar condition is reported in the fibula.

3. The aetiology of congenital deformities has been briefly discussed, and a short review made of the relevant literature.

4. A plea has been made to withhold amputation until a more prolonged investigation is done in cases of this type.

I wish to acknowledge my indebtedness to Mr. Matthew White, in whose wards the case was treated; and to Professor D. M. Blair for help and encouragement in the preparation of this paper.

REFERENCES

BAGG, H. J., *Amer. Jour. Anat.*, 1929, **43**, 167.
DARESTE, C., *Jour. de l'Anat. et Physiol.*, 1882, **18**, 510.
FELL, H. B., *Jour. of Morphol. and Physiol.*, 1925, **40**, 417.
FELL, H. B., *Arch. f. exper. Zellforsch.*, 1928, **7**, 390.
GEGENBAUR, C., *Morphol. Jahrb.*, 1876, **2**, 396.
GOODRICH, E. S., *Structure and Development of Vertebræ*, 1930.
HARRIS, H. A., *Bone Growth in Health and Disease*, 1933.
HOFFA, A., *Münch. med. Woch.*, 1890, **37**, 237.
LERICHE, R., and POLICARD, A., *The Normal and Pathological Physiology of Bone*, trans. by S. Moore and J. A. Key, 1928. London.
MURRAY, P. D. F., *Bones. A Study of the Development and Structure of the Vertebrate Skeleton*, 1936. Cambridge.
NIVEN, J. S. F., *Roux's Arch.*, 1933, **128**, 480.
NUZZI, *Chir. d. Org. di Movemento*, 1920.
OLLERENSHAW, R., *Jour. Bone and Joint Surg.*, 1925, **7**, 528.
SCHMID, O., *Sur le Rôle de l'Amnion dans les Malformations congénitales*, 1902. Paris.
VIRCHOW, R., *Virchows Arch.*, 1865, **32**, 518.
WALLS, E. W., *Lancet*, 1940, **1**, 123.

FRACTURES OF THE HEAD AND NECK OF THE RADIUS*

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THIS paper is based on an investigation of 459 cases of 'recent' fractures of the head and neck of the radius treated at the Liverpool Royal Infirmary during the 10-year period 1927–37. In addition, a few cases treated elsewhere have been utilized to demonstrate certain points.

A number of papers have been written during the past fifteen years, notably those of Cutler,[1] Key,[2] Bohrer,[3] Fleming,[4] and Buxton,[5] each dealing with various aspects of this subject, but this investigation I think represents the first attempt to follow up a large number of cases over a long period.

Incidence.—When this investigation was begun these 459 cases were thought to be the total number of fractures of the head and neck of the radius treated during the 10-year period, but this has since been found to be erroneous, the actual total being 722. This number represents an incidence of 44 per cent of all elbow fractures, and 4·5 per cent of all fractures treated at the Liverpool Royal Infirmary. This type of fracture, then, is of very frequent occurrence, and is in fact the commonest fracture about the elbow-joint. In all probability the figures should be even higher, as the symptoms are frequently so mild that a bony lesion is apt to be missed. In none of the cases investigated was the fracture compound.

Types of Fracture (*Fig.* 53).—Many terms have been used to describe the different varieties of fracture of the head of the radius. In the present series the following types occur :—

1. *Simple Crack.*—A small crack is present in any part of the head without displacement.

2. *Marginal.*—The fracture line crosses the joint surface and cuts off a portion of the periphery, usually the antero-lateral portion. The size of this marginal fragment varies, but usually consists of about one-third of the articular surface and in most cases is very slightly depressed.

3. *Marginal with Displacement.*—As the name implies, the fracture line is similar to that of Type 2, but the marginal fragment is displaced. In the majority of cases it is badly depressed and angulated, but in a few it is completely separated and lies free in the elbow-joint.

4. *Flake.*—This is a rare type which I had not recognized before carrying out this investigation. X rays show a thin strip of bone apparently torn from the periphery of the head and hanging over the orbicular ligament. Its appearance is quite different from that of even the most peripheral of marginal fractures.

5. *Comminuted.*—The degree of comminution is variable, but in most cases the head is completely crushed and distorted, frequently with fragments separated and lying loose in the joint.

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* Based on a paper read before the British Orthopædic Association at the Spring Meeting at Oswestry, 1939.

6. *Fracture of the Neck.*—This most commonly is a greenstick fracture occurring in children, but it does occur in adult life. An interesting type associated with a comminuted fracture of the head will be referred to later.

Table I shows the actual number and percentage of each type occurring in the total of 459. It will be observed that the simple crack and marginal types easily constitute the majority (61 per cent). Little attention should be paid to the relative proportion of these two types as the distinction between them is not absolute, and probably many of the simple cracks should really be regarded as marginal.

Complicated Fractures.—Included in the figures of *Table I* are 70 fractures (i.e., 15 per cent) complicated by the presence of other injuries to the elbow,

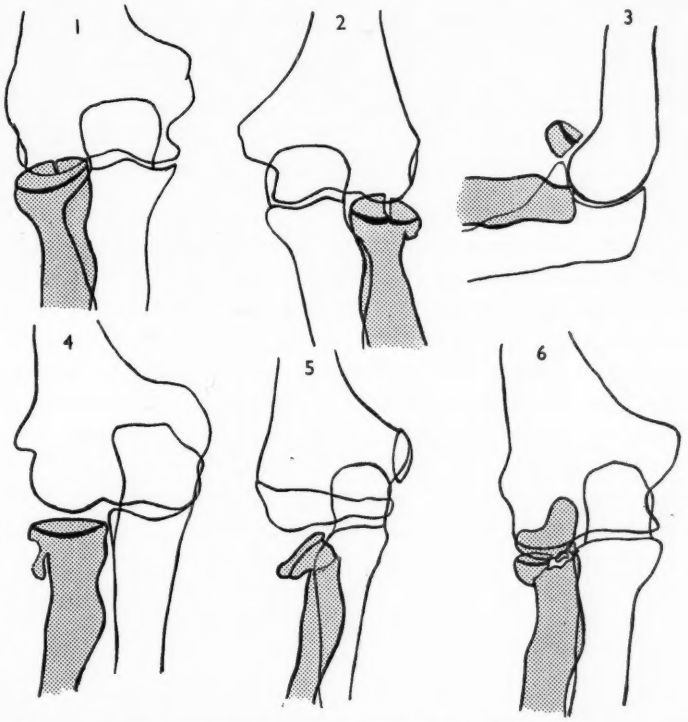


FIG. 53.—Tracings of radiographs showing varieties of fracture: 1, Simple crack; 2, Marginal, slightly depressed; 3, Marginal, with complete separation; 4, Flake; 5, Greenstick of neck; 6, Comminuted.

forearm, or wrist. Although all types, with the exception of the flake fracture, are represented among these complicated fractures, it is the more serious injuries which are commonly associated with complications. For example, of the 46 comminuted fractures enumerated in *Table I*, 22 (48 per cent) were complicated, while only 2 out of 88 (2 per cent) simple crack fractures were complicated.

Easily the most frequent complication was an associated dislocation of the elbow, which occurred in 28 cases, fractures of the coronoid process coming second with 16 cases. Fractures of the olecranon and upper end of the ulna occurred in 11, fractures involving the wrist in 9, the external condyle 6, the internal epicondyle 3, and the external epicondyle in 2 cases. In addition there were 2 cases of musculospiral palsy and 1 of early Volkmann's contracture, all of which fully recovered. In several cases more than one of these complications were concurrent.

Age Incidence.—*Table I* shows the age incidence of the different types. In the third column of figures the limits of each range are given, while the last column indicates the age period in which the majority of fractures of each type occur. This I think is more helpful than working out the average age for each type.

Table I.—Types of Fracture and Age Incidence

Type	Number	Percentage	Range	Majority of Cases
Simple crack	88	19	13–62	18–30
Marginal	192	42	15–71	18–35
Marginal with displacement	60	13	18–63	25–45
Flake	9	2	13–42	13–42
Comminuted	46	10	24–66	35–55
Neck	64	14	3–55	9–18
Total	459	100		

These figures point to a definite relationship between age and type. It is well known that the majority of fractures of the neck occur in children ; the number of flake fractures is too small to be of any significance ; but in the remaining groups it would appear that the older the patient, the worse the degree of injury is likely to be.

Mechanism of Injury.—In the literature there is disagreement among authors on this subject. Cutler[1] reported a series in which direct violence was said to be the cause in twice as many cases as indirect violence, and this preponderance is agreed upon by many authors. But I very much wonder if this so-called direct violence has not been misinterpreted. In the present series, with few exceptions, the notes simply state that the patient fell on his hand, fell on his elbow, or fell injuring the elbow ; and the actual figures are 109 due to a fall on the hand and 188 due to a fall on the elbow. These figures agree roughly with Cutler's findings, if a fall on the elbow is to be regarded as a proof of direct violence to the head of the radius. This in my opinion is the fallacy.

There are a few cases of simple cracks and of comminuted fractures, but none of marginal or neck fractures, in which the violence was undoubtedly applied directly to the head of the radius, e.g., the direct impact of a golf ball. The usual story is a fall to the ground, and it is extremely difficult to fall in such a way that the head of the radius impinges on the ground. Furthermore, it is rare to find evidence of injury to the overlying skin, and difficult to correlate the X-ray appearances with direct violence. It seems much more probable that in the majority of cases the head is crushed against the external condyle of the humerus, in the same way that the outer tuberosity of the tibia is crushed against the condyle of the femur. If this view is correct, the so-called falls on the elbow are really falls on the bent forearm, resulting in forcible abduction and flexion at the elbow-joint.

In addition to what has been said above, there is much evidence to support this view. In the present series there were 6 fractures of the external condyle shown by X rays (*Figs.* 54–56), but in addition 5 of the elbows opened at operation revealed injuries of the articular surface of the capitellum. Among the operation cases 12·5 per cent were proved to have injuries of the capitellum, and there is no

reason to suppose that this figure would be much lower among cases treated conservatively. In one case a portion of articular cartilage from the capitellum

FIG. 54.—Fractured neck of radius associated with outward dislocation of the elbow and fracture of the external condyle.

FIGS. 55, 56.—Marginal fractures associated with minor fractures of the external condyle.

was actually found wedged in the fracture of the head. Another relatively common finding is evidence of injury to the internal lateral ligament of the elbow-joint, indicating an abduction strain. Bruising and tenderness over the inner side of

FIG. 57.—Greenstick fracture of neck of radius associated with avulsion of internal epicondyle.

FIG. 58.—Fracture of neck of radius treated by open reduction six years previously, showing avulsion of internal epicondyle.

the elbow are common, but in 3 cases of this series the internal epicondyle was avulsed (*Fig.* 57), and in several others radiographs taken years later showed evidence of injury to the epicondyle (*Figs.* 58, 63) and sometimes ossification in the internal lateral ligament (*Fig.* 61, C). A study of the radiographs in most cases of marginal and neck fractures reveals how the head comes in contact with the external condyle, and demonstrates the part which abduction plays in these injuries. It is interesting to observe, if this theory is correct, that the position of a marginal fracture depends on the degree of pronation at the time of the fall; thus, the more the pronation, the more posterior will be the fracture.

Finally the relative frequency of associated dislocations and fractures of the coronoid process indicates the type of violence. B. J. Hein, in a discussion

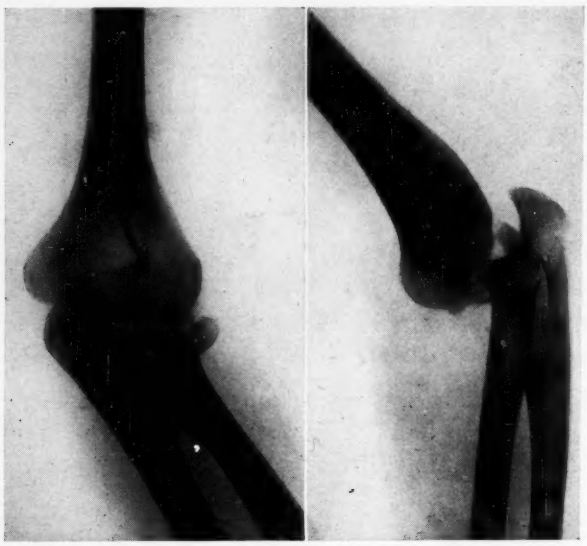
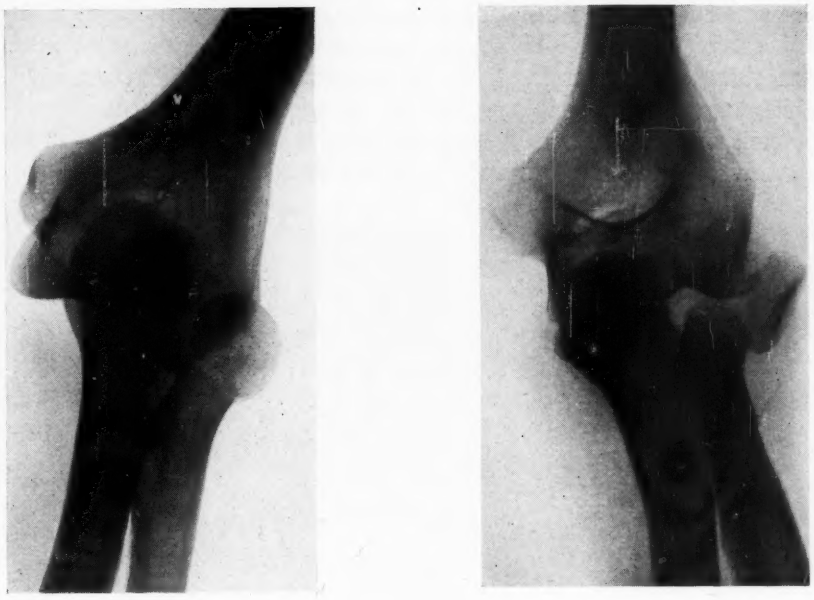


FIG. 59.—Comminuted fracture of head associated with fracture through neck and dislocated elbow. Note backward rotation of largest fragment.

following a paper by Key,[2] said, "Dislocation is of sufficient frequency to be considered part of the process which fractures the upper end of the radius." In this connection I would like to describe an interesting type of comminuted fracture in which there is a fracture through the upper part of the neck. There were 5 such cases in this series, and in all there was a large rotated segment involving the posterior half of the head, together with an anterior marginal fragment (*Fig.* 59). In 3 of these cases there was known to be a dislocation of the elbow, and I suggest that dislocation was present in the remaining cases, but was reduced spontaneously. The likely explanation is that the patient falls on the bent forearm or hand, the head is crushed against the capitellum prior to dislocation, and the large posterior fragment is rotated when the elbow is reduced (*Fig.* 60).

All this supports the theory, not of course a new one, that fractures of the head and neck of the radius are nearly all caused by indirect violence. I now question patients very carefully, and it is surprising to find how seldom they can describe accurately the manner of injury unless it happens to be a fall on the hand. The

frequency with which a fall on the elbow is recorded is probably explained by the fact that the patient knows that he has hurt his elbow, and therefore imagines that he must have fallen on it.



A B

FIG. 60.—A, Fracture through neck of radius associated with backward dislocation of elbow, head not displaced; B, Dislocation of elbow reduced, head completely displaced.

TREATMENT

Treatment may be either conservative or operative, but by far the majority of cases are treated conservatively. In this series of 459 cases, 401 (87 per cent) were treated conservatively and 58 (13 per cent) by operation.

1. Conservative Treatment.—In most cases all that is necessary is rest of the elbow in full flexion in a collar-and-cuff sling for ten days to three weeks, according to the severity of the lesion. In complicated fractures full flexion may not be posssible at once owing to swelling, but in the other types swelling is usually negligible; flexion may also be limited by a displaced fragment, but such a fracture would rarely be treated conservatively. In simple cracks without displacement gentle active movements both of rotation and of flexion and extension are allowed from the start, the sling being discarded in from ten days to a fortnight. In marginal fractures it is wiser not to allow any movement for ten days, and the same is true for greenstick fractures of the neck. Comminuted fractures, depressed marginal fractures, adult fractures of the neck, and most complicated fractures require three weeks' rest in full flexion before starting movements. In all cases active exercises of the hand, wrist, and shoulder are insisted on from the start. In some of the early cases of this series massage and passive movements were employed about the stage when the sling was discarded, but these were found to delay recovery and were abandoned as harmful.

Manipulation was carried out in a few cases of displaced marginal fragments with relatively little success, but more often for fractures of the neck with angulation. In the latter group it is a most useful measure, and from my own experience I think it probable that the majority of greenstick fractures of the neck, with the usual backward and inward angulation, could be reduced by manipulation if treated early (*Fig.* 61). This does not agree with Key's observations. The important thing while carrying out the manipulation is to remember how the fracture was caused, and forcibly to perform the opposite movements, viz., adduction and extension, with the thumb pressed firmly on the back of the head of the radius. This manœuvre is facilitated in most cases by supination.

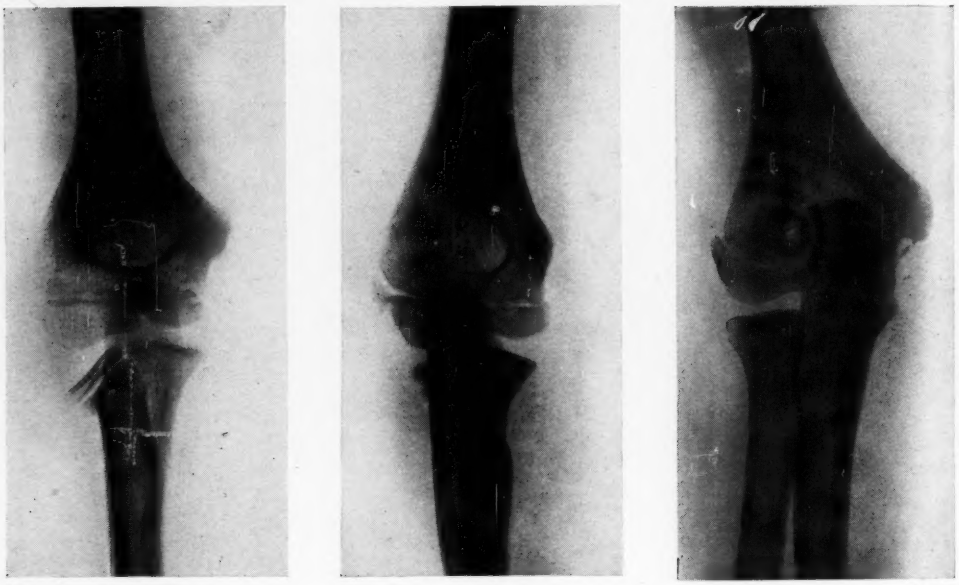


FIG. 61.—Greenstick fracture of neck treated by manipulation: A, Before manipulation; B, After manipulation; C, One year later—note 'droplet' ossification below internal epicondyle.

2. Operative Treatment.—Analysis of the 58 cases treated by open operation shows that the indications for operation were as follows:—

1. Gross comminution, 32 cases.
2. Marginal fractures with marked depression, 12 cases.
3. Loose fragments in the joint, 6 cases (5 marginal, 1 flake).
4. Fractures of the neck with angulation which manipulation failed to reduce, 7 cases.
5. Failed conservative treatment, 1 case (marginal).

Three types of operation were performed:—

1. *Total Excision of the Head.*—This was performed in 23 cases of badly comminuted fractures, and 5 depressed marginal fractures.

2. *Partial Excision.*—This operation, which consists of removing loose or badly displaced fragments, leaving the greater part of the head in situ, was performed on 13 marginal fractures, 9 comminuted fractures, and 1 flake fracture. Among the

marginal fractures there were some with completely separated fragments, and some with unseparated but depressed fragments. Apparently, at any rate for several years of the investigation period, partial excision was the operation of intention for the depressed marginal type, but fortunately in several cases the damage to the head was found on exposure to be greater than had been suspected from the radiographs and total excision was performed instead. The results of total excision were found to be better than those of partial excision for this type of case (*Table IV*) and total excision became the operation of choice. The same applies to comminuted fractures, and now the only remaining indication for partial excision is the presence of completely separated fragments, the greater part of the head being relatively undamaged.

3. *Open Reduction.*—This operation was reserved for fractures of the neck with angulation in children, and was performed 7 times. The average age of these patients was 10½ years, ranging from 9 to 13, and in all cases manipulation was performed first.

Technique.—The approach is the same for all three types of operation. A curved incision is made extending 1 in. along the external supracondylar ridge of the humerus down to the epicondyle, and then carried downwards across the subcutaneous surface of the head of the radius to a level just below the neck. The upper part of the incision allows adequate retraction of the supinator longus and extensors of the wrist, and in muscular subjects partial division from their origin may be necessary to allow a good exposure. The capsule of the elbow-joint is opened in the line of the incision and the head of the radius exposed. In most cases it is not necessary to expose the neck; it is not so much the fear of injury to the posterior interosseous nerve, as the importance of preserving the orbicular ligament intact, which sets the lower limit of the deep incision.

Through this incision loose fragments can be removed and total excision can be performed piecemeal, the head being rotated so that every part of it comes into view in turn, the remaining stump of the neck being finally rounded off with a fine pair of bone cutters. Unfortunately in the third type of operation, open reduction, it is usually necessary to divide at least part of the orbicular ligament, a significant fact which will be referred to again.

RESULTS OF TREATMENT

In order to arrive at a correct impression of the end-results of these fractures, an effort was made to see all cases at least a year after the accident, but this attempt was not altogether successful. In actual fact 227 cases (nearly 50 per cent of the total) were examined from one to ten years after the accident, and this number includes nearly all the more serious fractures. The majority not seen were those with trivial injuries, discharged after a few weeks with practically normal function, or who ceased to attend after a few days because they regarded the injury so lightly. Unfortunately the exclusion of all these cases means the exclusion of a large number of the best results, and this might give rise to an unjustifiably poor impression of the results of treatment. I have therefore included 127 additional patients who attended regularly for treatment, and who were seen at the routine follow-up clinic six months after discharge. Even so, I feel sure, for the reasons mentioned above, that the results would have been even better if the remaining 105 cases could have been traced. In all, 354 cases are included in the follow-up review, the average follow-up period being 2½ years.

In the follow-up examinations the following were the chief points considered :—

1. Anatomical appearance of the elbow.
2. Range of movement in elbow and radio-ulnar joint.
3. Symptoms and function.
4. Complications, including possible changes in the wrist.
5. Disability period.

In regard to range of movement, three standards were set: (*a*) Absolutely full range; (*b*) Slight limitation, i.e., 10° or less of any movement; and (*c*) Limitation of any movement by more than 10°. (I realize now that 10° is setting too fine a standard, and it would have been better to have extended the middle group to 20°.)

Under the heading 'Symptoms and Function', elbows were again divided into three classes: (*A*) Painless and strong; (*B*) Minor symptoms, e.g., slight aching or a little weakness; (*C*) More serious symptoms, e.g., severe pain or marked loss of power.

Changes in the wrist unfortunately were not studied as closely as I would now wish, and minor abnormalities may have been missed. There were, however, no gross changes such as radial deviation of the hand and prominence of the ulnar styloid in the whole series of cases followed up.

Conservative Treatment.—The results of conservative treatment are summarized in *Table II*, and these figures are much what one would expect. It will be observed that no comminuted fractures apparently were treated conservatively; in actual fact there were several, but all were complicated, and complicated fractures are considered in a group by themselves.

Table II.—Results of Conservative Treatment (percentages in brackets)

	Crack	Marginal	Marginal with Displacement	Neck	Flake	Complicated
Range of Movement :—						
a. Full range	52 (78)	77 (60)	11 (37)	28 (74)	4 (80)	15 (37·5)
b. Slight limitation (10° or less)	9 (13)	27 (22)	5 (16)	5 (13)	—	8 (20)
c. Greater limitation than 10°	6 (9)	24 (18)	14 (47)	5 (13)	1 (20)	17 (42·5)
Symptoms and Function :—						
A. Painless and strong	32 (75)	74 (75·5)	14 (56)	29 (85)	3 (75)	22 (71)
B. Minor symptoms	10 (23)	23 (23·5)	11 (44)	5 (15)	—	8 (26)
C. Loss of power or other severe symptoms	1 (2)	1 (1)	—	—	1 (25)	1 (3)
Disability period (weeks)	4·4	6·6	8·0	6·7	6·0	9·8

It is evident from these figures that the simpler the injury the greater is the chance of recovery of full range of movement. The contrast between the displaced marginal type with only 37 per cent recovery of full range of movement and the simple crack with 78 per cent is very striking. Analysis of the cases with limitation of movement greater than 10° shows that extension is the movement most frequently affected. Of 67 cases of all types, limitation of extension occurred in 92 per cent, of flexion in 31 per cent, and of pronation and supination each 23 per cent. In

the simple fractures without displacement extension was usually the only movement affected, while in the complicated fractures and fractures with displacement movement was commonly limited in several directions.

In the same way the disability period in this series was proportional to the severity of the fracture. The only remarkable feature in *Table II* is the very low percentage of cases with severe symptoms, compared with the relatively high percentage of cases with considerable limitation of movement. This is especially the case in the displaced marginal type, in which 47 per cent had limitation of more than 10° yet among them there was not a single patient with severe symptoms. It is remarkable even with 30°–40° limitation of movement how seldom the usefulness of an elbow is affected, and how seldom a patient complains of the limitation. In the whole series only 4 cases have been found with Class *C* symptoms; they are the following:—

Case 1.—Female, aged 49, simple crack fracture, seen four years later with full range of movement, but crepitus and symptoms of osteo-arthritis.

Case 2.—Female, aged 43, marginal fracture without displacement, seen five years later still complaining of pain, but with full range and no abnormal objective signs.

Case 3.—Male, aged 36, flake fracture treated elsewhere by massage, seen two years later complaining of pain and having the following limitation of movement—extension 25°, pronation 40°, supination 90°.

Case 4.—Male, aged 22, marginal fracture complicated by musculospiral palsy, seen three years later still complaining of pain and weakness, and having limitation of flexion 25°, supination 70°.

Operative Treatment.—Of the 58 cases treated by operation, 46 have been seen from six months to ten years after operation, the average time being three and a half years. The results are summarized in *Table III*. On the whole it is my impression that the earlier the operation was performed after the accident the better the result. Buxton,[5] on the contrary, prefers to delay operation for six weeks.

Table III.—Results of Operative Treatment (percentages in brackets)

	Total Excision	Partial Excision	Open Reduction
Range of Movement :—			
a. Full range	8 (35)	4 (25)	1 (14)
b. Slight limitation (10° or less)	2 (9)	2 (12·5)	—
c. Greater limitation (than 10°)	13 (56)	10 (62·5)	6 (86)
Symptoms and Function :—			
A. Painless and strong	16 (84)	14 (87·5)	6 (86)
B. Minor symptoms	3 (16)	2 (12·5)	1 (14)
C. Loss of power or other severe symptoms	—	—	—
Disability period (weeks)	18	10	

Once again, as in the conservative group, it is remarkable how seldom severe symptoms persist in spite of marked limitation of movement. Many elbows with

gross limitation of one or more movements were painless and strong, and there was not a single Class *C* result among the operation cases traced.

FIG. 62.—Massive new-bone formation around head and neck of radius, following partial excision of head for comminuted fracture. Radiograph taken eighteen months after operation.

Table III shows the results in regard to range of movement to be better with total excision than with partial excision. This is the more significant when it is known that the injuries treated by total excision were in most cases more severe than those treated by partial excision. Some of the worst results were among comminuted fractures treated by partial excision, i.e., removal of one or two loose fragments, leaving the remainder of the head in situ. In such cases there is a tendency to new bone formation around the head and neck (*Fig.* 62).

The superiority of total excision over partial excision is more clearly shown when one type of fracture, viz., the displaced marginal, is considered (*Table IV*). Although the numbers are small, it is clearly demonstrated that total excision resulted in a better range of movement than did partial excision in the majority of fractures of this type; the good results of partial excision were mostly cases in which simply a loose fragment was removed.

At the same time a fair comparison can be made between conservative and operative treatment for this type. *Table IV* shows that as good results can be obtained by conservative as by operative treatment, but it should be remembered that in the conservative group the displacement was seldom so marked, and there were no cases of completely detached fragments.

The only other type in which conservative and operative treatment can be fairly compared is the green-stick fracture of the neck. The majority of these fractures were treated conservatively, and it was only those with fairly marked deformity which were manipulated, and again only those which failed to respond to manipulation which were subjected to open reduction. Although the greater number of those not manipulated had no appreciable deformity, there were among them 9 cases with definite, though slight, deformity. When these were followed up, every one was found to have a full range of movement. There were also 9 cases with more marked deformity treated by manipulation, and of them 8 were found to have a full range of movement when followed up. These figures (100 per cent and 89 per cent full range) contrast strongly with those in *Table III*, in which it appears that only 1 out of 7

FIG. 63.—Radiograph taken seven years after open reduction of neck. Only apparent abnormality is deformity of internal epicondyle due to avulsion.

Table IV.—Comparison of Conservative and Operative Results in Marginal Fractures with Displacement (percentages in brackets)

	Conservative	Operative	Total Excision	Partial Excision
a. Full range	11 (37)	6 (37·5)	3 (60)	3 (27)
b. Slight limitation (10° or less)	5 (16)	2 (12·5)	1 (20)	1 (9)
c. Greater limitation (than 10°)	14 (47)	8 (50)	1 (20)	7 (64)

(14 per cent) patients who underwent open reduction obtained a full range of movement. In the remaining 6 cases there was a very severe degree of limitation, ranging from 15° to 90°, confined in 5 out of the 6 to radio-ulnar movement. So startling and disappointing was this finding, that a special investigation was made of this group. The more important details of each case are given below.

Case 1.—Male, aged 9, complicated by avulsion of internal epicondyle. Operation seven days after accident; no difficulty in reduction. Seven years later still had complete absence of pronation; other movements full. X rays showed an apparently normal upper end of radius, but evidence of old injury to internal epicondyle (*Fig.* 63).

Case 2.—Female, aged 10. Operation three weeks after accident; partial division of neck necessary before reduction could be obtained. Eight years later still had complete absence of pronation, other movements full. X rays showed an apparently normal elbow.

Case 3.—Male, aged 13. Operation four weeks after accident; partial division of neck necessary before reduction could be obtained. Six years later still had 60° limitation of pronation; other movements full. Unfortunately a new radiograph was not obtained.

Case 4.—Male, aged 13. Operation two weeks after accident; head found completely detached. Complete reduction never obtained, and when seen fourteen months later had limitation of flexion 35°, extension 10°, pronation 40°, supination 65°. X rays showed the neck to be still slightly distorted, with new-bone formation around it. This patient has not been traced since.

Case 5.—Female, aged 10. Operation one week after accident; no difficulty in reduction. Three years later had 15° limitation of both pronation and supination; other movements full. X rays showed an apparently normal elbow-joint.

Case 6.—Female, aged 9. Operation one week after accident; no difficulty in reduction. Two years later had 45° limitation of supination; other movements full. X rays showed an apparently normal elbow-joint.

Case 7.—Male, aged 10. Operation eighteen days after accident; separation of fragments necessary. Two years later had full range of movement and radiographs appeared normal.

Several remarkable facts appear from a study of these cases. Of the 6 patients with limited movement, 3 had limitation of pronation only, and 1 of supination only; the fifth had limitation of both pronation and supination, while the remaining case had limitation in every direction. This last was the only one with X-ray changes to offer an explanation, the remainder (with the possible exception of one not X-rayed) showing practically no radiological evidence that a fracture had ever occurred in the neck of the radius. Bohrer[3] has reported a series in children in which proliferative periostitis followed operation in a high percentage of cases. In the present series this only occurred in the one case in which perfect reposition

was not obtained; furthermore this was the only case in which any movement other than rotation was affected. This, therefore, is not the explanation for the limitation of rotation. I imagine that the explanation must be found in the formation of adhesions between the neck and the orbicular ligament divided at operation, and suggest that this might be one of the few conditions of the elbow which could be benefited by manipulation.

Complications.—Schwartz and Young[6] state that removal of the head is always followed by deformity and instability; and Bohrer states that removal of the head in children is almost invariably followed by an increase in the carrying angle, and frequently by synostosis. In this series removal of the head was never carried out in children, but among adults there have been only 2 cases of definite cubitus valgus amounting to an increase of 20°, and 1 case with slight lateral mobility. It has already been mentioned that there were no cases with obvious secondary changes in the wrist, and the only other complication following operation was 1 case of myositis ossificans, following total excision for a comminuted fracture, associated with a dislocated elbow.

CONCLUSIONS

1. Fractures of the head and neck of the radius are the commonest fractures involving the elbow.

2. The majority result from indirect violence, the head being crushed against the capitellum.

3. Treatment: For the vast majority should be conservative. For fractures of the neck with displacement early manipulation should be carried out, and open reduction undertaken only as a last resort. For a completely detached fragment displaced into the joint, removal of the fragment is necessary. For comminuted fractures, total excision of the head. For depressed marginal fractures, either conservative treatment or total excision of the head, but not removal of the depressed fragment only.

I wish to thank Mr. Watson-Jones for his kind permission to carry out this investigation; Mr. Norman Roberts for his valuable advice in the early stages; and Mr. P. B. Moroney for his courtesy in assisting with the follow-up of cases and providing certain statistics.

REFERENCES

[1] CUTLER, C. W., *Ann. of Surg.*, 1926, **83**, 267.
[2] KEY, J. A., *Jour. Amer. Med. Assoc.*, 1931, **96**, 101.
[3] BOHRER, J. V., *Ann. of Surg.*, 1933, **97**, 204.
[4] FLEMING, C. W., *Proc. Roy. Soc. Med.*, 1932, **25**, 1011.
[5] BUXTON, ST. J. D., *Brit. Med. Jour.*, 1936, **2**, 665.
[6] SCHWARTZ, R. P., and YOUNG, F., *Surg. Gynecol and Obst.*, 1933, **57**, 528.

TESTICULAR TUMOURS

NINE CASES, INCLUDING EPIDIDYMOMA AND CHORIOMA

By A. WILFRID ADAMS, Bristol

Testicular tumour is certainly rare, but equally incumbent is it upon us not to overlook it. It is of fell significance, for the vast majority are malignant. Timely operation may both cure locally and save dissemination, yet experience shows that doctors are apt to dismiss such swellings as tuberculous if small, or as hydroceles if large. The easy removal so urgently needed is dangerously postponed.

Their aetiology, while of paramount importance to the pathologist, merits brief allusion here, for it bears on the practical problem of treatment. Most writers attribute them to aberrant germ-cells which, instead of maturing as spermatozoa, lie dormant until the period of sexual activity. Their reproductive energy finds vicarious expression in disordered proliferation of protean histology. This conforms with the totipotent capacity of germ-cells. Usually the ancestral cell predominates, and the resulting tumour qualifies as a seminoma; but a notable capacity for structural elaboration may result in a conglomeration of mature tissues, epithelial and connective, as a teratoma. It is in the latter that the ultra-malignant manifestation of chorionepithelioma sometimes supervenes. Only very rarely are tumours found in the epididymis. Trauma and malposition are suspect as predisposing factors (Dew[1] and Gordon Taylor[2]).

DIAGNOSIS

Testicular tumours occur mainly in the middle third of life, with a slow painless history. The body of the testis enlarges, the epididymis becomes stretched over it and loses its identity. The resulting lump is firm and more or less smoothly ovoid. Old hydrocele or hæmatocele with thickened sac or gumma need differentiating, but, if the possibility of neoplasm is remembered, the diagnosis can usually be made; or doubt is dispelled by exploration. A tumour so nearly naked surely need not defeat us! Yet the fact remains that they come to the consultant wrongly labelled and even after prolonged medication.

Disease of the scrotal contents is common, but tumour rare and therefore often missed. The outline of the elastic testis remains a distinct entity from an enlarged epididymis. The latter is occasionally anterior (inversion). In October, 1939, I performed epididymectomy on R. W., aged 29 years, for a caudal swelling due, I thought, to tuberculosis. Biopsy disproved that, but kept histologists guessing between neoplasm or chronic epididymitis. The latter was the final verdict.

Testicular tumours often secrete a male *sex hormone* which is found in the urine. After orchidectomy it disappears, but the return of a positive test points to metastatic activity. This is a useful guide to prognosis and the effectiveness of treatment by operation or radiation. Barlow[3] alludes to its commoner presence in teratomata and to the importance of sampling the morning urine.

TREATMENT

One of the cases in the series dealt with in the past seven years was beyond surgery. In the remaining 8 cases the operative mortality was nil, although the radical operation, embracing removal of the pre-aortic glands, was undertaken in 4 cases. Survival periods are stated in the case reports.

THE RADICAL OPERATION

In addition to ablation of the testicle and spermatic vessels, this includes exposure of the aorta and removal of vessels, fascia, and glands draining lymph from the testicle. As is likely after such interventions, intestinal distress has been notable at times. The extended procedure must be regarded as a major one. I am, so far, encouraged to persist with it, and quote the following case in support :—

Case 1.—W. T., aged 48 years, was admitted in January, 1935, with *two years'* history of painless swelling in the right testicle. This was removed in continuity with its vascular pedicle and a pre-aortic gland, enlarged to half the size of a walnut, near the origin of the spermatic vessels. The pathologist found seminoma present at both sites (*Fig.* 64).

In April, 1940, 5 years later, he looked well and no recurrence was discoverable. One could hardly have expected this had the cancerous aortic gland not been removed in 1935.

A brief recital of my three other cases will serve to show the feasibility of the operation :—

Case 2.—C. B., aged 31 years, came with recurrent swelling of the left testicle of *one year's* duration. He was well otherwise. On July 10, 1936, I removed the enlarged organ, which measured 3 in. in its long axis. No glands were found on the aorta. The histological finding was rapidly growing seminoma. He was given deep X-ray therapy.

Three years later he was quite fit and the urine free from male sex hormone.

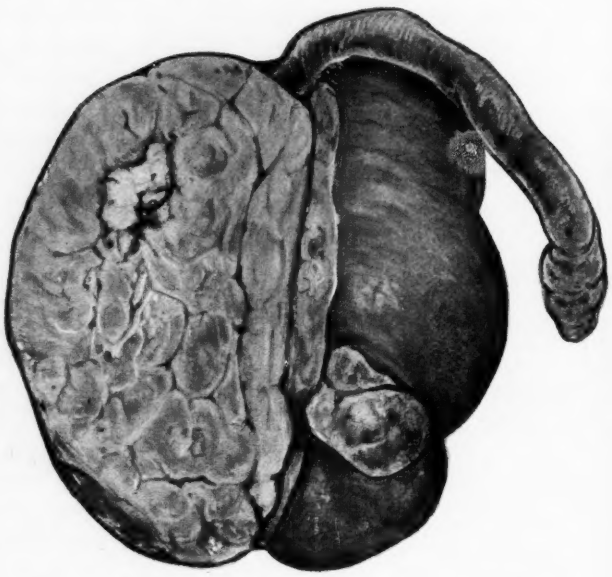


FIG. 64.—*Case* 1. Seminoma of testis and aortic gland. Patient alive and well 5 years later.

Case 3.—F. G. F., aged 51 years, had a swelling for *eight months* in the right testicle. Rapid increase occurred in the last six weeks. The testicle, enlarged about four times and having smooth nodes on it, was removed on March 4, 1938. Four or five glands, a little swollen, were dissected off the aorta. The former was reported as a highly malignant seminoma, while the latter showed only considerable inflammatory change. Eighteen months later he was quite well and his urine hormone-free.

Case 4.—J. A. S., aged 28 years, had steady enlargement of the right testicle for *six months*. It measured 3 in. × 2 in. At orchidectomy on June 25, 1938, three small pre-aortic glands were removed. The testis was seminomatous, but the glands devoid of metastases. So far he is well.

THE LOCAL OPERATION

Four cases had only the testicle and adjacent cord removed. Their stories are instructive. In two no outlying spread was detected clinically, but they died about twelve months later with metastases.

Case 5.—H. T., aged 34 years, had a swelling of the right testicle for *twelve months*. He looked well. The lump was like a large hydrocele, with the characteristic tendency to hour-glass shape. Histology showed teratoma. Death from secondaries occurred a year later.

Case 6.—A. B., aged 17 years, came as a recurrent hydrocele from the Casualty Department where foments had recently been given for hæmatoma *following a kick* on the left scrotum. Histological examination showed a rapidly growing seminoma. At post-mortem, ten months after operation, there were metastases in the lumbar lymphatics, liver, and right parietal pleura.

Case 7.—R. I. M., aged 22 years, provided a rarity. I was called in to find him acutely ill, apparently with a hypogastric *appendix abscess*. For three months he had felt lassitude and had lost weight. For the last three weeks anorexia was present, but he had not been confined to bed. His colour was waxy and tongue furred. Pulse 140 and temperature 100°. Through a midline incision I found a large neoplasm with tortuous vessels filling the pelvis. Only the sex of the patient forbade a diagnosis of solid ovarian tumour. It was rather fixed and its main connections were to the region of the left internal abdominal ring. At this stage the growing suspicion of a *cancerous abdominal testicle* was confirmed by a belated discovery of an empty left scrotum. After freeing two loops of ileum which had grown on to it, the tumour was extirpated. This restored him to fair health, but no more than a few months' life. Secondary deposits were already obvious in the mesentery and along the lumbar aorta. On biopsy the tumour proved to be a seminoma, with necrosis and hæmorrhages.

A CASE OF SEMINOMA EPIDIDYMIS

Seminoma arising in the epididymis is of peculiar interest and import. Firstly, there is the great rarity of the tumour, and to the 25 cases previously reported (Herman[5]), the following is now added. Secondly, as an exception to a clinical rule it is apt to deceive the most experienced. The rule is that tumours arising in the body of the testis stretch the epididymis out of recognition, merging the two components of the testicle in a single, solid, ovoid mass. This finding should suggest malignant disease. By contrast, when two elements are distinguishable and thickening is felt in the posterior, it invites a diagnosis of epididymitis.

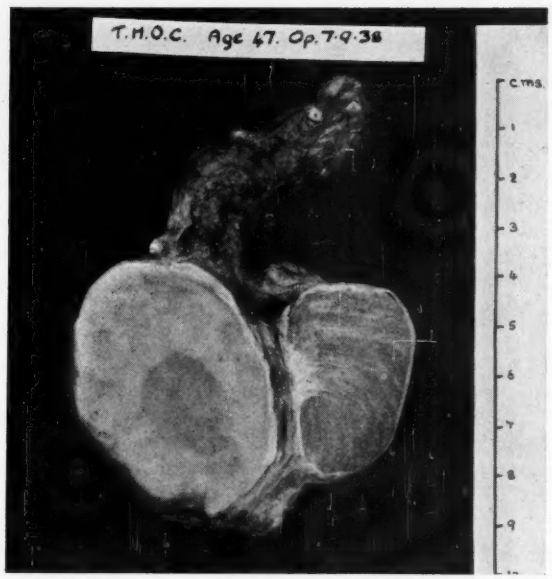


FIG. 65.—*Case* 8. Seminoma epididymis.

Case 8.—My patient, T. C., aged 47 years, had the latter type of tumour for *two years*, he stated. The swelling was notably firm, but had not the hard, craggy outline of tuberculosis. There was no history of inflammation, no tenderness, infiltration, or adhesion, and the Wassermann reaction was negative. The notion of neoplasm had

to be reluctantly accepted and I did not hesitate to press orchidectomy (*Fig.* 65). Twelve months have passed since operation. He is following his occupation as a gardener and is free from any sign of disease. His urine is hormone-free.

This exemplifies well the alert mind with which to approach testicular swellings.

A CASE OF CHORIONEPITHELIOMA TESTIS

In the period during which the preceding cases were treated, one inoperable case was seen. This is described below.

Tumour of the testis is always ominous. In the form of chorionepithelioma it is a terror. No sooner has it made its presence felt, usually in a young man, than through its vascular meshwork it showers the viscera with its seeds. The

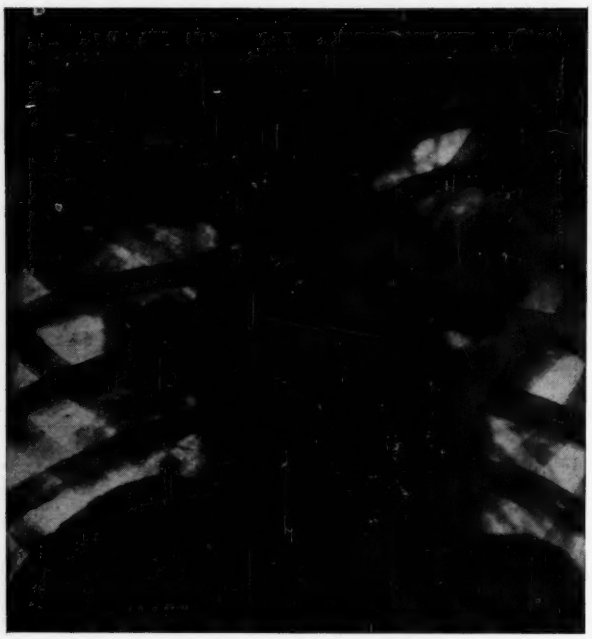


FIG. 66.—*Case* 9. Chorioma testis. Metastases in lungs.

secondary masses, equally vascular, rupture in the lung or stomach with external hæmorrhage, or affect the brain. In a few weeks the victim is vanquished, as the following story corroborates :—

Case 9.—F. A. B., aged 29 years on Feb. 26, 1939, said that six weeks previously he was examined in connection with his occupation and deemed ' fit.'

Three weeks ago he saw the doctor for pain and swelling in the right testicle, which had been present a few days. He developed pyrexia, severe epistaxis, hæmoptysis, and for the last two or three days repeated vomiting (including streaks of blood), insomnia, severe headaches, and visual disturbance. This illness suggested tuberculosis to his doctor.

He was a pale, weary, and somewhat wasted man, intelligent but amblyopic. The body in general revealed no localized trouble, save that the right testicle was the size of a lemon and had a posterior promontory on it. It was hard, and on its ovoid surface rose a slight nodule near the lower pole, while in front it gave the feeling of blood-clot moving in a layer of fluid. No breast changes were noted.

Radiographs of the lungs showed circular opacities varying in size from a marble to a golf ball (*Fig.* 66).

Blood test showed anæmia only. Urine, otherwise normal, injected into a mouse gave a strongly positive Aschheim-Zondek reaction six days later, and on that day the man died.

Post-mortem examination: The testicle was the seat of chorionepithelioma. A little yellow testicular substance survived. There was a small mass beside the lumbar aorta and scattered deposits in the liver, lungs, and brain. The left occipital pole had a deep excavation which had lodged a nodule about 1½ in. in diameter. This remained on the dura when the brain was extracted from the skull, as in Cooke's[6] case. All the secondary deposits, like the primary tumour, on section were dark red and amorphous, like recently organizing blood-clot. Dr. A. D. Fraser describes it as a mixed-tumour type of teratoma with slight chorion-epithelioma, and the metastases as mostly chorionepitheliomatous.

Can We Circumvent Chorionepithelioma?—How often it starts as a primary neoplastic change in the testicle is a moot point. Cooke[7] observes that in about 50 per cent of recorded cases teratomatous elements have been present in addition, and it is logical to suspect that chorioma often supervenes where a less active tumour has been lurking for months or years.

Teratomatous tumours form 80 per cent of the benign tumours of the testicle (Herman[8]), and since they are slow growing, and chorionepithelioma notably rapid, it seems evident that, where the two are conjointly present, chorioma must be regarded as a secondary development on pre-existing teratoma. When enquiry was repeated, my patient agreed that a different sensation was present in the right testicle for some months. In Jackson's[9] case slight, sluggish enlargement had existed for three years prior to sudden rampant expansion.

The only effective time to treat this exceedingly fatal form of cancer is before it has declared its distinctive features. Once it is recognized clinically, the march of the illness is too rapid for the surgeon to overtake. In practice, every testicular swelling, unless clearly explicable by an alternative diagnosis, must be considered as a new growth and as the potential vehicle of the deadly seed of chorioma. If extirpated while clinically in the prechoriomatous stage, then, and then only, may it be caught in time.

SUMMARY

Nine cases are reported. One, of seminoma testis with lumbar metastases, remains well at 5 years, thanks to the radical operation; a second is a seminoma epididymis, and a third is a chorionepithelioma which was inoperable.

Diagnosis is discussed and copious evidence adduced that every dubious testicular swelling should promptly be explored.

The special danger of this relatively rare, but deadly, tumour is its clinical resemblance to common disease of the testicle, with consequent delayed operation.

Treatment comprises radical orchidectomy and, in the light of present knowledge, deep radiotherapy subsequently.

REFERENCES

[1] DEW, H. R., *Malignant Disease of the Testicle*, 1924, 61.
[2] GORDON-TAYLOR, G., and TILL, A. S., "On Malignant Disease of the Testicle with Special Reference to Neoplasm of the Undescended Organ", *Brit. Jour. Urol.*, 1938, **10**, 1.
[3] BARLOW, D., "Malignant Disease of the Testicle", *Jour. Clin. Research*, 1939, July, 105.
[4] HINMAN, *Surg., Gynecol. and Obst.*, 1919, **28**, 495.
[5] HERMAN, L., *The Practice of Urology*, 1938, 672.
[6] [7] COOKE, J. V., *Bull. Johns Hopkins Hosp.*, 1915, June, 217.
[8] HERMAN, L., *Ibid.*
[9] JACKSON, H., *Jour. Amer. Med. Assoc.*, 1919, Dec. 20, 1868.

CRITICAL REVIEW

SEPTICÆMIA

By L. E. H. WHITBY, C.V.O., M.C., Colonel, Army Blood Transfusion Service

THE state of *septicæmia* is caused by the entry of bacteria into the blood-stream, where the organisms multiply, and by reason of the multiplication exert a toxic action on the tissues of the body which is frequently fatal. In *pyæmia* not only is there septicæmia, but the circulating bacteria have also a tendency to aggregate and to lodge as emboli in end-organs and joints and there readily lead to the formation of abscesses. With pyæmia there is usually an extensive primary focus of infection. Both these pathological states have to be distinguished from *bacteriæmia* in which condition bacteria are present in the blood-stream, and do indeed multiply there so that they may be demonstrated by blood-culture, but the blood-stream invasion is only the preliminary phase of a more defined disease process. Examples of bacteriæmia are the early stages of typhoid fever and, often, the invasive stage of lobar pneumonia.

Portals of Entry.—The disease is frequently cryptogenic, so that no portal of entry can be discovered, but there is no doubt that virulent and invasive organisms may penetrate an unhealthy mucous membrane, especially in the pharynx, without exciting a local reaction sufficiently characteristic for a clinical examination to differentiate it from any other local inflammation. Moreover, abrasions of the skin may be microscopic only, and here again the local reaction following upon penetration by organisms may be so small that even if not unnoticed it may nevertheless appear almost trivial. Usually the portal of entry is clear or may be surmised with fair confidence. In parturient women the large raw area of the placental site provides a ready entrance for bacteria. With an extensive local focus of infection, such as cellulitis or osteomyelitis, there is always a danger of blood-stream invasion, whilst septicæmia is the usual accompaniment of spreading gangrene, more especially if this arises from an infective thrombosis. In some, the injury caused by a dental extraction or by ill-timed surgical interference with a vascular but not purulent inflammatory lesion may let loose organisms into the blood-stream; in others, the inoculation may be accidental from a minute cut or a prick, and it is obvious that the risk of septicæmia is great with war wounds, when there is great laceration of tissue and involvement of deep structures; in others, septicæmia may be the terminal condition of an infective disease which finally invades the blood-stream after having worn down the local and general resistance of the infected subject.

Bacteria.—The bacteria most commonly responsible for the cryptogenic and puerperal forms of septicæmia are β-hæmolytic streptococci of group A and, occasionally, groups B, C, D, and G; in puerperal cases the streptococcus is sometimes an anaerobe. β-hæmolytic streptococci are also the menace that lies hidden in a sometimes minute wound acquired in the post-mortem room or

operating theatre as well as in the extensive wounds of war. Septicæmia may be caused also by *Staph. aureus*, *Staph. albus*, α-hæmolytic streptococci (*Str. viridans*), inert streptococci, pneumococci, *Cl. welchii*, and, indeed, in debilitated subjects or in those who receive a large and virulent inoculation almost any bacterium may be found. Gonococci, meningococci, *Bact. friedländeri*, *Bact. coli*, *P. vulgaris*, and *Ps. pyocyanea* are some of the rarer causes of septicæmia. The terminal stages of anthrax, glanders, and bubonic plague are usually septicæmic.

The majority of the pyogenic cocci are ubiquitous, but there are nevertheless certain sources of infection which can be eradicated or avoided. β-hæmolytic streptococci are frequently carried in the pharynx. A nurse or attendant so infected may unwittingly be the cause of septicæmia at the time of childbirth, at what would otherwise have been a clean surgical operation, or at the time of dressing a clean wound. Fleming and Porteus (1919) estimated that a high proportion of streptococcal infections in war wounds were contracted by droplet infection from those who carried out the dressings. α-hæmolytic streptococci and inert streptococci are much more widely distributed. One or other or both may be isolated from the mouth or pharynx of everyone, frequently from the apices of teeth, even though these do not appear to be infected, from fæces, from air, from soil, and from clothing. Staphylococci, usually the non-invasive *albus* type, may be isolated from the skin, mucous membranes, and a large number of extraneous sources. The invasive *aureus* variety is carried on the hands of operators with moderate frequency (Devenish and Miles, 1939).

PATHOLOGY

The Defences against Blood-stream Implantation.—Very few organisms have the power of penetrating an intact skin or mucous membrane, though it would appear that *B. anthracis* and the gonococcus can in their respective spheres both readily effect this in the human subject. In almost all cases of septicæmia in which the organisms have a superficial portal of entry there is a break, perhaps microscopic, in the integument.

In healthy subjects the blood has a remarkable bactericidal power and is quickly able to deal with quite considerable numbers of bacteria, but the result is greatly influenced by the invasive power of the organism implanted as well as the amount of the implant. Debilitated persons, such as alcoholics or those afflicted with constitutional diseases, for example nephritis or diabetes, have but little power in the terminal stages of their disease of resisting even avirulent bacteria. The implantation of quite small numbers of bacteria directly into the blood-stream usually causes some systemic febrile reactions. Thus, there is abundant evidence that the rigors which so frequently follow the extraction of an infected tooth are due to a transient bacteriæmia. In this instance, and in most other cases, small implants in healthy persons are usually quickly engulfed by phagocytic polymorphonuclears which are derived from the bone-marrow in large numbers in response to the bacterial chemiotactic stimulus. But when such direct blood-stream implants consist of highly virulent and invasive bacteria then there follows the acute fulminating type of septicæmia with rapid blood-stream multiplication against which even an abundant bone-marrow reaction is generally ineffective.

Many cases of septicæmia arise by a spreading from a local focus into the blood-stream. It is indeed a remarkable tribute to nature's protective power that

this grave accident does not occur more frequently. The essential protection is provided by the vascularized fibrinous or fibroblastic framework which comprises the familiar granulation tissue and which walls off an exposed, injured, or infected tissue from the rest of the body. Were it not for the activity of the phagocytic cells present in such tissue and in the blood, combined with the natural bactericidal action of the blood and tissue fluids, everyone would quickly die from septicæmia. Granulation tissue has ample power to deal with reasonable numbers of bacteria unless they are highly invasive. Whether an infection remains local, spreads extensively, or enters the blood-stream, depends on many factors. If it is a case of wounding, the chance of invasion is influenced by the amount and the nature of the tissue wounded, for some tissues have more power of localizing an infection than have others. The immediate protection of the body against septicæmia in any case of wounding is the reaction of inflammation which consists in the outpouring of lymph and phagocytic blood-cells at the site of the wound. The longer that this reaction can keep a local bacterial implant from multiplying or invading the blood-stream, the greater is the body's opportunity for exerting its more permanent protective action, namely, the production of granulation tissue. Sometimes the actual size of a local implant completely overwhelms any attempt by the body to produce the protective barrier of granulation tissue. Thus, in pyæmia, a large embolus may produce a local collection of pus which will continue to spread even though efficiently opened, this because the speed of the pus production has outrun the speed with which the barrier can be erected. Since both of the protective reactions—the immediate and the late—are fundamentally of vascular origin, it is obvious that the tissues most resistant to bacterial invasion are those with an abundant blood-supply. This is the explanation why the peritoneum and other serous membranes, which are capable of a rapid reaction of inflammation and so of localization of an infection, are not more often the portal of entry for a frank septicæmia. On the other hand, mechanical conditions may render a tissue unable to be resistant to septicæmia despite very considerable vascularity. Thus, in osteomyelitis the abundant thin-walled veins of the cancellous tissue are heavily compressed by the inflammatory exudate owing to the unyielding nature of the surrounding bony structures. This readily leads to infective thrombosis and so to pyæmia.

Elimination of Infection.—The final stages in recovery from any septicæmia depend upon the ability of the body to produce antibacterial substances in sufficient quantity to prevent multiplication and render the bacteria susceptible to phagocytic destruction. This provides the rationale for treating the disease with appropriate specific sera and also for blood transfusion, which is believed to supply complement and other substances which are frequently lacking. Almost an axiom of recovery is that any local focus which is responsible for the blood-stream infection shall have been eliminated, localized, or rendered incapable of feeding the blood-stream further. Sometimes when there appears to be no local focus, recovery is greatly assisted by the development of one, because this serves as a nidus for fixing the bacteria that would otherwise be circulating in the blood-stream. The observation of this clinical fact is the basis for treating septicæmia by a so-called 'fixation abscess'.

Morbid Anatomy.—The fatal lesions produced by bacteria in septicæmia are due either to the action of toxins on essential tissue or to the occurrence of embolic abscesses in vital places. To toxic action is due the cloudy swelling and

(should life endure long enough) the fatty degeneration which is found in the heart muscle, liver, and kidneys. Focal necroses in the liver are common, whilst the spleen is enlarged, pulpy, and so diffluent as to be almost fluid. Small subserous and submucous hæmorrhages as well as subcutaneous petechiæ are almost invariable; these are sometimes due to toxic action on the vascular endothelium and at others to the lodgement of infected emboli. Thrombosis and embolic phenomena, including multiple abscesses and hæmorrhagic infarcts, are common. Post-mortem staining of the endothelium of the aorta and large blood-vessels is almost always present.

DIAGNOSIS

Clinical.—Outstanding clinical features of septicæmia are rigors, sweats, and a hectic pyrexia which may exhibit daily remissions or intermissions or may simply rise steadily. Hæmorrhages, petechial or purpuric, are almost invariably found, if not on the skin then on the mucous membrane or the fundus of the eye. A feature which has great diagnostic value in the more chronic forms of the disease is the occurrence of small hyperæmic nodes, especially on the fingers; these sometimes suppurate and sometimes do not; they are due to lodgement of emboli. With hæmolytic infections there is always an icteroid tinge to the conjunctiva if not to the skin, and in severe cases, such as *Cl. welchii* infection, marked jaundice may quickly occur. Prostration, wasting, and emaciation rapidly develop. In severe forms of the disease and in debilitated subjects there is almost always delirium and often a typhoid state. Objective signs and symptoms include poor heart-sounds due to a dilated heart and a pulse which is small, soft, and rapid. The tongue is brown, dry, and furred and there is marked anorexia. There may be extreme constipation or troublesome diarrhœa. There is often much dyspnœa, with Cheyne-Stokes respiration in the terminal stages. From the clinical aspect septicæmia is closely imitated by deep-seated local inflammation such as an hepatic abscess, by the hæmorrhagic forms of the acute infectious fevers, and by a number of acute diseases such as leukæmia, infective endocarditis, and typhus fever, which are characterized by purpura, fever, and toxæmia. A clinical diagnosis should be confirmed by blood-culture.

Laboratory.—Absolute proof of the disease is given by demonstrating organisms in the blood by means of a blood-culture. This is best carried out by a skilled pathologist. Negative results do not always exclude the disease, because certain types of infection tend to be intermittent. Cultural conditions should be arranged to ensure the growth of any likely organisms, and it is customary to make at least three cultures, one of which is incubated under aerobic conditions, another anaerobically, and the third in an atmosphere containing a high percentage of carbon dioxide. A skilled bacteriologist will make use of appropriate media and so greatly increase the chance of a positive result (Butler, 1937). A positive blood-culture has not always a grave significance. The early phases of pneumococcal pneumonia are commonly associated with a bacteriæmia which does not increase the gravity of the prognosis unless persistent. After dental extractions or even after passing a catheter, a positive blood-culture can often be obtained within a short time of the operation, and here again the finding has no serious significance unless it persists for more than a few hours. As to staphylococcal infections, significance is usually attached to the *aureus* variety, but not to the *albus*. But if

the test is performed by a skilled pathologist and a positive result is obtained in duplicate cultures and in repeated cultures, the *albus* infection cannot be disregarded. Chronic streptococcal septicæmia and infective endocarditis are not excluded by a negative blood-culture.

Indirect evidence of septicæmia is provided by other blood examinations, though these do not specifically distinguish septicæmia from serious local sepsis. Septicæmia from virulent hæmolytic organisms actually destroys some of the circulating red cells, but a more potent cause of the inevitable anæmia is the highly toxic action which is exerted on the marrow tissue itself. In acute and virulent infections, rapidly increasing anæmia is usual and the red-cell count may quickly be reduced to as low as two million per c.mm.; the hæmoglobin is proportionately decreased. An acute hæmolytic anæmia is particularly characteristic of *Cl. welchii* infection, in which condition about half the circulating blood may be destroyed in a few hours, leading to hæmoglobinæmia, hæmoglobinuria, and quickly developing jaundice. It is remarkable how quickly such a hæmolytic anæmia is recovered from once the primary cause has been eliminated. The usual anæmia of septicæmia is progressive, extremely intractable to treatment with hæmatinics, and responds only temporarily to blood transfusion. The leucocyte changes depend largely upon the severity of the infection. In favourable cases with a good resistance, a total white-cell count of thirty to forty thousand per c.mm. may be expected; polymorphonuclears predominate in the count, and primitive cells, myelocytes and myeloblasts, may be present, especially in young subjects. Occasionally, the blood-count is both high and sufficiently primitive in character to suggest leukæmia. A minor hæmatological point which helps in prognosis is that eosinophils disappear entirely from the circulation during the grave phases of the illness and return again if recovery occurs; the reappearance of these cells may be regarded as a hopeful sign. In unfavourable cases, those that are severely toxic and overwhelmed by their infection, leucopenia is present from the outset or may appear during the course of the disease; this leucopenic type of count is especially common in staphylococcal septicæmia.

PROGNOSIS

The prognosis in septicæmia is extremely variable and can only be estimated with any accuracy by a careful assessment of all the aspects of the case. The aged, the debilitated, and those with severe constitutional disease have usually a gloomy outlook whatever the organism and whatever the primary cause, which is indeed often obscure. In the young the disease is frequently fatal, overwhelmingly sudden in onset, and unbelievably swift in termination, but with youth the power of reaction is great and of recovery even greater; recovery, which is often unexpected and dramatic, should never be despaired of. Of clinical signs, a low temperature with a rapid pulse is a much more grave sign than a high temperature. The same interpretation may be put on a low leucocyte count, which indicates paralysis and collapse of the defensive mechanism. Delirium, coma, and rapid loss of weight are serious signs. The cryptogenic and acute fulminating forms have the worst prognosis, but even in these types the outlook is now greatly improved on account of chemotherapy. In puerperal cases the mortality from β-hæmolytic streptococcal infections has been significantly reduced by the efficient use of sulphanilamide. Provided a primary focus can be efficiently dealt with, then the prognosis in

hæmolytic streptococcal infections is now good because of the effectiveness of sulphonamide treatment. Staphylococcal infections have a high mortality, more especially on account of the tendency for infective thrombosis to be a feature of the disease, as well as the fact that many strains of staphylococcus are only feebly affected by the known sulphonamide derivatives. Furthermore, there is often a difficulty in dealing with the local focus, particularly with lesions about the face, as well as with deep-seated bony infections. *Cl. welchii* septicæmia is almost always fatal once the liver has become seriously involved, but even this grave disease may yet be found to be amenable to chemotherapeutic treatment. Suppurative pylephlebitis with consequent fatal pyæmia has a grave, almost hopeless, prognosis.

TREATMENT

General Measures.—The ultimate result in cases of septicæmia may be greatly influenced by surgery, by specific treatment, and by chemotherapy, but the final elimination of the infection rests entirely with the patient. Nursing, attention to detail, nourishment, are vital, and, if possible, any vicious circle causing a progressive deterioration in general condition should be broken. The patient should be at complete rest in bed. Food should be as generous as the diminished appetite allows, whilst the fluid intake should be as high as possible in order to encourage sweating, to ensure a reasonable urinary output, and to avoid the almost inevitable dehydration. Fever should be controlled by tepid sponging and not with antipyretic drugs. Fresh air is essential; the sick room should be light and airy, and when practicable nursing in the open air is to be recommended. Anæmia is but a symptom of the general disease and therefore only responds efficiently to removal of the primary cause. Hæmatinics are of little value, but small transfusions of fresh blood not only tend to check a progressive anæmia but also help to increase general resistance and so to aid recovery. Septicæmic patients are said to lack complement; fresh blood supplies this. Transfusions of 250–400 c.c. may be given every five to seven days.

Prophylaxis in the Case of Wounds.—Most medical men must at some time have thought about what they would do were they to receive a wound when dealing with an obviously infected patient or when doing a post-mortem. As the result of such an injury one of three things may happen. Firstly, the infecting organism may be inoculated direct into the blood-stream, in which case, owing to the speed of the blood-stream, no local measure, however quick, can prevent the dissemination. Secondly, the infecting organism may be inoculated into the tissue spaces and either give rise to a local abscess or cause an ascending lymphangitis, which, in due course, may result in septicæmia. Thirdly, nothing may happen, either because no inoculation is made or because the organism is quickly overcome. As an immediate measure there is much to be said for the encouragement of free bleeding by the application of a light tourniquet, the free-flowing blood being washed away under a tap. Caustics and strong antiseptics should be avoided, as these cause tissue necrosis which encourages the growth of any implanted organisms; iodine or acriflavine may be used, but the best dressings, if such are available, are either hypertonic saline, or hypertonic magnesium sulphate, or urea, all of which stimulate an outward flow of lymph. However busy a medical man may be he is taking an unnecessary risk if he does not cease work at once and go to bed for at least 48 hours with the affected part immobilized; he should, of course,

remain in bed if there is the slightest evidence of local or general reaction at the end of this time. During the period in bed a prophylactic course of the appropriate sulphonamide drug should be taken in full dose, namely, 1 g. four hourly night and day, and this should be continued unless everything appears well at the end of 48 hours.

There is now considerable experimental evidence (Nitti, 1939) to show that packing of a recent wound with 5–15 g. of sulphanilamide holds up and may indeed eliminate an implanted infection. When there is a definite wound local application should therefore be made, in addition to the oral course recommended above.

Surgical Principles.—From the surgical aspect it is imperative to carry out any procedure which will remove a primary focus or which will prevent such a focus from feeding organisms into the blood-stream. In relation to this it is important carefully to distinguish a primary focus from a primary portal of entry. There is no point in removing a finger after a needle prick in it has resulted in blood-stream implantation with multiplication, unless there is a persistent local focus. Lymphangitis and adenitis, too, are more often protective manifestations than signs calling for amputation. But there is every reason for dealing with a purulent serous cavity such as an empyema or any suppurating focus which obviously contains pus and for allowing free drainage for any definite inflammatory exudate. Particular infections demand particular treatment. Most coccal foci of infection are better not incised until the pus is laudable. It is indeed a mistake to incise lesions which are in the stage of hyperæmia that precedes pus formation. It should also be borne in mind that the formation of an abscess sometimes serves to localize an infection and definitely to save life. In these circumstances premature opening of the abscess is to be avoided. The production of an artificial fixation abscess by the injection of 1 drachm of turpentine beneath the skin is favoured as a method of treatment by some authorities. Gas gangrene infection, by reason of the widespread damage which is caused, demands extensive dissection and complete removal of even partially infected muscles because the organisms are always found well in advance of any clinical lesion. In osteomyelitis some surgeons advocate non-operative treatment, but in general the principle of removing the infecting focus which is feeding the blood-stream with septic emboli must be regarded as sound. Staphylococcal lesions of the face are particularly apt to give rise to septicæmia; they demand ligature of the angular vein in order to prevent spread of infections to the cavernous sinus, but any interference with the local focus itself is to be strongly condemned.

Specific Therapy.—When appropriate sera are available they may be used to supplement chemotherapeutic treatment. There is considerable evidence that the sulphonamide group of drugs exert their action by inducing bacteriostasis, and that the final elimination of the infection requires the co-operation of the immunity mechanisms of the host. For this reason, therefore, small doses of the concentrated antitoxic sera of streptococcus, staphylococcus, and *Cl. welchii* should be used when there is much toxæmia. Except in chronic low-grade infections with little or no febrile and general reaction, vaccines are useless and even dangerous.

Chemotherapy.—The discovery of the sulphonamide group of drugs has greatly improved the prognosis in septicæmia. Dosage, route of administration,

and choice of compound vary with each individual case. As a general principle, a large initial dose of the appropriate compound is desirable in order quickly to obtain an adequate concentration of the drug in the blood. When facilities are available it is as well to check this point by a blood estimation a few hours after beginning treatment. The blood content should reach and be maintained at not less than 10 mg. per cent. If this level is not reached with an oral preparation, then subcutaneous, intramuscular, or intravenous injection should be used as a supplement. The oral preparations serve for most purposes, and they have the advantage of being slowly and continuously absorbed over a period of time, thus maintaining an adequate blood level. During administration fluid intake should be generous. Soluble preparations for injection or injections of sulphanilamide itself (which is soluble in water to the extent of 1 per cent) are more rapidly absorbed than oral preparations, but they are also excreted more rapidly. Numerous injections are therefore necessary if a soluble preparation is used as the sole method of treatment. Intravenous administration is only required in fulminating or neglected cases. The parenteral route has to be used when swallowing is not possible, when nausea and vomiting are prominent symptoms, when absorption from the alimentary canal is inadequate, and for immediate treatment in urgent and neglected cases.

It is now known that these compounds are effective when applied to a wound, where they exert a local action and are slowly absorbed into the blood-stream. A War Office Memorandum (1940) recommends the packing of war wounds with 5–15 g. sulphanilamide at the earliest moment and particularly at the time of débridement. The earlier the application is made the more likely is prophylaxis to be effected.

The duration of treatment has to be decided for each individual case. Where these drugs are effective the result is usually obvious within a few days. If no action is noticed within ten days it is useless to pursue treatment with that particular drug. Prolonged courses tend to cause a fatal agranulocytosis and a number of other distressing and sometimes dangerous symptoms. If a first course of ten days is not entirely effective, an interval of three days should be allowed before beginning a fresh course. For the second course a change of preparation is often an advantage. When dangerous symptoms caused by the drug arise during the course of treatment the blood-stream can be rapidly cleared by inducing diuresis with water.

The prime factor in determining choice of compound is that the organism shall be susceptible. The following table (modified from Buttle, 1940) with footnotes sets out the range of activity of the commoner compounds :—

Infecting Organism	*Sulphanilamide*	*Sulphapyridine*	*Sulphathiazole*
Str. hæmolyticus	+ + +	+ + +	+ + +
Pneumococcus	o	+ + +	+ +
Staphylococcus	±	+	+
Str. viridans	o	±	+
Meningococcus and gonococcus	+ +	+ + +	—
Cl. welchii	+ +	+ +	—
V. septique	±	+	—
Cl. œdematiens	o	o	—
Bact. coli	+ +	+ +	+ +

Notes : (1) Rubiazol has approximately the same range of activity as sulphanilamide.
(2) Proseptasine (benzylsulphanilamide) has the same range as sulphanilamide, but is much less potent.
(3) —, No data available ; o, No action.

Choice of Preparation.—

Oral Preparations: Sulphanilamide (sold under trade names which include Sulphonamide P, Streptocide, Colsulanyde, Prontosil album) is markedly active against most β-hæmolytic streptococci, meningococcus, gonococcus, *Bact. coli* and *Cl. welchii*, but is relatively inactive against staphylococcus and has no appreciable action on pneumococcus and *Str. viridans*. The drug is well tolerated by the mouth and is probably the compound of choice for empirical treatment of a suspected hæmolytic streptococcal infection. A daily dose of 1 g. per 20 lb. of body-weight (maximum 6 g.) should be given for the first two days, in equally divided doses administered four-hourly night and day. Children require a 50 per cent larger dose in proportion to body-weight than do adults. After two days the total daily dose should be reduced by 1 g., and after a further two days the remainder of the course of ten days should be at the rate of 3 g. per day. Sulphanilamide may also be applied locally to a wound.

The benzyl compound, proseptasine, has approximately the same range of activity as sulphanilamide, but it less soluble, is less toxic, and less powerful. This compound is of great value for, and is more suitable for, the treatment of less serious diseases than septicæmia.

Rubiazol, a French preparation closely allied to sulphamidochrysoidin (the original oral preparation known as prontosil) has the same range of activity as sulphanilamide and is sometimes better tolerated.

Sulphapyridine (M & B 693) has a wider range of activity than sulphanilamide, being effective against all the organisms influenced by the latter as well as against pneumococcus, whilst it is more effective against staphylococcus, *Str. viridans*, and *V. septique*. Sulphapyridine is therefore the best drug for empirical use when the nature of the infecting organism is uncertain from the clinical aspect, and cannot be proved by blood-culture. A dosage similar to that for sulphanilamide may be used. A certain number of cases have difficulty in taking the drug by mouth because of vomiting and nausea, which may be severe enough to prohibit adequate treatment. In all cases it is advisable to powder the tablets and suspend the powder in milk; in this form the drug is usually well tolerated.

Sulphathiazole, a compound described by McKee, Rake, Greep, and Van Dyke (1939), is very similar to sulphapyridine in range of activity and has the advantage of being more soluble and therefore more regularly absorbed, as well as of causing less vomiting. Animal experiments of my own in 1938 indicated that this compound had a considerable action on pneumococcus and staphylococcus, but was on the whole inferior to sulphapyridine. Nevertheless, on account of the great variation in strain susceptibility which characterizes pneumococcus and staphylococcus a change to sulphathiazole should certainly be made in any case in which sulphapyridine appears to be feeble or ineffective. The drug also acts on *Str. fæcalis* (Helmholtz, 1940). The dosage is the same as that for sulphapyridine. The compound is marketed in England by Messrs. May & Baker.

Parenteral Preparations: Owing to the rapidity with which soluble preparations are excreted, it is necessary to make frequent injections in order to maintain the blood concentration at an efficient level. Hence it is not now usual to rely on soluble preparations alone. The main uses of the compounds are to initiate treatment in fulminating and neglected cases and to supplement an oral preparation, especially if there is nausea and vomiting or poor absorption as shown by a blood estimation.

The most efficient and potent preparation is the soluble sodium salt of sulphapyridine, which is supplied in ampoules of 3 c.c., each containing 1 g. The solution is highly alkaline and must be injected deep into muscle if pain is to be avoided and in order to prevent necrosis in subcutaneous tissue. It can be injected intravenously if diluted with 20 c.c. of saline. The dose of this preparation is 1 g. repeated not more often than once in four hours.

Prontosil Soluble (Bayer) is made as a 5 per cent solution and is still obtainable; the total daily dosage should not exceed 0·5 c.c. per lb. of body-weight (maximum 60 c.c.) divided into six doses administered during 24 hours. Soluseptasine (May & Baker) requires an even larger 24-hour dose (200 c.c. divided into six portions), which makes administration tedious to the patient. Soluseptasine is sufficiently non-toxic to be given intravenously. Both these last two compounds have the same range of activity as sulphanilamide.

EFFECTS OF MODERN TREATMENT

There is abundant evidence from the literature that a combination of all that was best in the older forms of treatment with efficient, intelligent, and appropriate chemotherapy has greatly improved the outlook in all common types of septicæmia. Nevertheless, because chemotherapy is known to be so effective when properly used, there is quite a considerable danger and tendency to rely on it alone, and this is greatly to be deprecated. For instance, no known sulphonamide compound will disperse a collection of pus, because the drugs are quite inactive in such a medium (Whitby, 1940; Fildes, 1940). Pus requires surgical treatment. And because it is well known that sulphonamide drugs have their dangers as well as their virtues, the timid are apt to prescribe small and therefore ineffective doses. A dangerous disease like septicæmia merits the taking of risks because the danger of death from the disease when treated with ineffective doses is far greater than the danger of death from toxic agranulocytosis when full and effective doses are used. With these principles in mind one can critically review the reported results. In hæmolytic streptococcal infections sulphanilamide has reduced the mortality from 40 per cent to 20 per cent in the puerperal form of the disease (Colebrook and Purdie, 1937; Gibberd, 1937). With pneumococcal septicæmia (Dyke, 1938) and with the bacteriæmia of pneumococcal pneumonia (Marriott, 1939), the effectiveness of sulphapyridine is freely acknowledged. Staphylococcal infections, on the other hand, have been less favourably reported upon and have been characterized by great variation from case to case. Successes have been claimed with sulphanilamide and many more with sulphapyridine (O'Brien and McCarthy, 1938; Goldberg and Sachs, 1939), including even desperate cases arising from facial lesions (Abramson and Flacks, 1939). The prognosis in staphylococcal septicæmia is greatly influenced by the ability to eliminate a primary focus. This, chemotherapy can rarely accomplish, and it is therefore difficult to assess efficacy unless each case is judged individually. The opinion of to-day is that chemotherapy should be undertaken in staphylococcal septicæmia; that in a simple septicæmia without extensive primary focus the prognosis is good, and that sulphapyridine is the best compound for first trial. But since strain susceptibility is a marked feature of staphylococcus, a change to sulphathiazole should be made if the first course is not effective.

Such few clinical cases of *Cl. welchii* septicæmia as have been reported indicate that both sulphanilamide (Sadusk and Manahan, 1939) and sulphapyridine (Baker,

1939) are efficacious. Animal experiments confirm this view, but suggest that better results are obtained in combination with specific antiserum (Stephenson and Ross, 1940).

Of the rarer types of septicæmia excellent results are reported in the case of meningococcus (Schwentker, Gelman, and Long, 1937) and even in a blood-stream infection of serious prognosis, namely, suppurative pylephlebitis due to *Bact. coli* (Ottenberg and Berck, 1938).

Chemotherapy has put such a powerful prophylactic weapon in our hands that this aspect should never be lost sight of. Relatively small numbers of bacteria can be rapidly mastered by sulphonamide drugs, but these may not be effective against the overwhelming numbers found in a fully developed infection. Obstetricians recognize the value of prophylaxis for all cases of childbirth with much instrumental interference or for a labour conducted in dirty or suspicious circumstances or for incipient or imminent peritonitis. They recognize equally that such prophylaxis is not necessary in every case. This should be the view of a surgeon. There should be no hesitation about instituting a 48-hour oral prophylactic course in cases of wounds liable to infection, and there is no doubt that this treatment combined with local application will enable wounds to be closed with greater safety and confidence. The same treatment, oral and local, should be given to compound fractures, and for this there is already reported evidence of efficiency (Jensen, Johnsrund, and Nelson, 1939). The discovery of the sulphonamide drugs has provided the surgeon with an invaluable ally which can reduce or control the triad of tragedies—sepsis, septicæmia, and pneumonia—any of which may rob the most masterful piece of surgery of its rightful triumph.

REFERENCES

ABRAMSON, A. W., and FLACKS, B., *Lancet*, 1939, **2**, 1065.
BAKER, J. K., *Ibid.*, 646.
BUTLER, H. M., *Blood Cultures*, 1937. London.
BUTTLE, G. A. H., *Lancet*, 1940, **1**, 890.
COLEBROOK, L., and PURDIE, A. W., *Ibid.*, 1937, **2**, 1237, 1291.
DEVENISH, E. A., and MILES, A. A., *Ibid.*, 1939, **1**, 1088.
DYKE, S. C., *Ibid.*, 1938, **2**, 621.
FILDES, P., *Ibid.*, 1940, **1**, 955.
FLEMING, A., and PORTEUS, A. B., *Ibid.*, 1919, **2**, 49.
GIBBERD, G. F., *Brit. Med. Jour.*, 1937, **2**, 695.
GOLDBERG, S. L., and SACHS, A., *Jour. Amer. Med. Assoc.*, 1939, **113**, 1639.
HELMHOLTZ, H. F., *Proc. Staff Meet. Mayo Clinic*, 1940, Jan. 31, 65.
JENSEN, N. K., JOHNSRUND, L. W., and NELSON, M. C., *Surgery*, 1939, **6**, 1.
MCKEE, C. M., RAKE, G., GREEP, R. O., and VAN DYKE, H. B., *Proc. Soc. Exper. Biol. and Med.*, 1939, **42**, 417.
MARRIOTT, H. L., *Brit. Med. Jour.*, 1939, **2**, 944.
NITTI, F., *Bull. de l'Acad. de Méd.*, 1939, **122**, 432.
O'BRIEN, E. J., and MCCARTHY, C. J., *Lancet*, 1938, **2**, 1232.
OTTENBERG, R., and BERCK, M., *Jour. Amer. Med. Assoc.*, 1938, **111**, 1374.
SADUSK, J. F., and MANAHAN, C. P., *Ibid.*, 1939, **113**, 14.
SCHWENTKER, F. F., GELMAN, S., and LONG, P. H., *Ibid.*, 1937, **108**, 1407.
STEPHENSON, D., and ROSS, H. E., *Brit. Med. Jour.*, 1940, 471.
War Office Memorandum, 1940.
WHITBY, L. E. H., *Practitioner*, 1940, **144**, 1.

SHORT NOTES OF RARE OR OBSCURE CASES

DISCOID LATERAL MENISCUS OF THE KNEE-JOINT WITH RUPTURE AND CYST FORMATION

By D. M. MEEKISON, Vancouver, Canada

History.—On March 20, 1939, W. D., a mill worker, aged 28, consulted the author concerning a disability of his right knee-joint. He stated that about 2.0 a.m. on March 16, four days previously, when pulling slabs off a chain, he slipped and his right knee gave out sideways. As far as he could tell, his knee was in a little flexion. At that moment, a slab, weighing probably 8 lb., fell from the chain and landed precisely over the lateral aspect of the right knee-joint. He states that the knee swelled up a little, but he carried on with some difficulty. He worked the next shift at another job, having rubbed the knee with liniment and bandaged it. At the end of this period he was unable to carry on. He stated that the knee had so stiffened that he was unable to move it.

The man's story was checked with his employers', and it was ascertained that he had worked for them for nearly a year at a rather heavy job which required a certain degree of agility. He had proved to be a conscientious workman and had made no complaint of disability. The man himself stated that he had had no previous trouble with this knee.

On Examination.—When examined, one noted over the outer side of the knee-joint, and probably posterior to the external lateral ligament, and in front of the biceps tendon, a definite cystic swelling which appeared to be very tender. It was about the size of a hazel-nut. It seemed to disappear on extension and right-angled flexion and was most prominent in semiflexion. There was no fluid demonstrable in the knee-joint, but there was pain on forced lateral movement with the leg in extension. There was no limitation of movement, but pain was complained of on complete extension or flexion.

On March 20, the day of the first consultation, an X-ray examination was made and antero-posterior and lateral views were taken. In these no sign of injury and no abnormal condition was seen.

On March 29 the cystic mass was aspirated under local anæsthesia and clear mucoid material was withdrawn with difficulty through a size 17 needle. The swelling was not decreased in size and was still very tender.

A diagnosis of cyst of the external semilunar cartilage of the right knee-joint was made, but in view of the apparent rapid development of this cyst, an orthopædic confrère, Dr. Boucher, was asked to see this patient. By April 12 no improvement was noted as the result of conservative treatment, and exploratory arthrotomy was agreed upon. He had been seen by a medical officer of the Workmen's Compensation Board shortly after the first consultation, and the findings were there also confirmed.

At Operation.—On April 21, 1939, at the Vancouver General Hospital, the author explored the lateral knee-joint, approach being made in front of the external

lateral ligament through a flap incision. A good view of the cartilage was obtained. The orthopædic surgeon who had examined the knee kindly came in to have a view. On opening the joint, what appeared to be a frayed upturned edge was seen just inside the external lateral ligament. The cartilage was separated anteriorly and the anterior attachment seemed to be quite broad. The joint was then approached from behind the external lateral ligament, and with little difficulty the cartilage was separated from its posterior attachment. In attempting to remove the lateral portion, a large cyst was entered and a considerable quantity of mucoid material escaped. The lateral attachment was removed, including some of the capsule. When the cartilage was delivered, it was found to be something more than semicircular in shape and could be best described as a discoid cartilage. It was about the size of a two-shilling piece and the same shape except that the one side was slightly flattened. The upper surface was very rough and there was a tear extending around two-thirds

FIG. 67.—Photograph of the ruptured discoid lateral meniscus.

of the periphery, running from before backward. At the posterior end of the tear there was a hæmorrhagic cyst the size of a small bean. The capsule, deep fascia, and skin were repaired and the joint was dressed with a pressure dressing.

PROGRESS.—Post-operative convalescence was very normal. The man was in hospital for twelve days and then discharged. An office note of May 8, 1939, states that the wound was perfectly healed and there was an excellent range of movement and no fluid. Exercises were advised, as there was a trace of atrophy. On May 22 physiotherapy was started.

The patient was finally examined and returned to work on July 20, 1939, apparently with a normal knee, and has continued to work since.

THE SPECIMEN.—The report from the pathologist on April 26, 1939, describes the specimen as consisting of " a considerably thickened semilunar cartilage, rough

on its superior aspect and on its lateral border, 1·5 cm. in thickness. It shows a rather circular laceration, extending practically entirely throughout its more peripheral portion. In the posterior aspect there is a small bean-sized cyst, which has a faintly pinkish tinge, and there is near it a portion of a collapsed cyst wall. Its medial border appears to be also slightly serrated. No sections were taken."

Comment.—This case is reported by reason of its numerous unusual features. To encounter a discoid cartilage is quite rare; to encounter a discoid cartilage with a tear is more rare; to encounter a torn discoid cartilage with cyst formation is unique.

INTRATHORACIC CYST OF INTESTINAL STRUCTURE

By M. F. NICHOLLS
ST. GEORGE'S HOSPITAL, LONDON

THE following description of a case of an unusual type of intrathoracic cyst seems worth recording, especially in view of the persistent misdiagnosis and misguided treatment.

HISTORY.—The patient, I. A., a girl 8 years old, was admitted to St. George's Hospital in 1935 with a history of chronic empyema and sinus. The history dated from 1931, when she had been treated elsewhere for right-sided "empyema pleuræ following pneumonia". This was aspirated and later drained by an open method. The sinus closed temporarily,

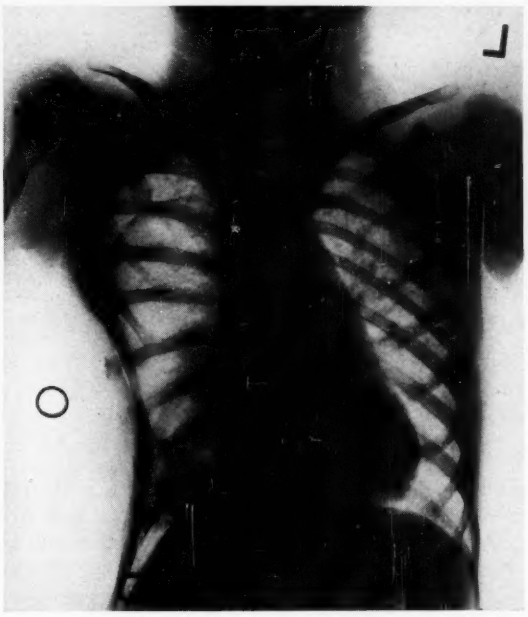


FIG. 68.—Radiograph, taken when the case was first seen in 1935, showing the cyst, deformity of the ribs, and scoliosis.

but later broke down and discharged. An interlobar collection formed and was drained, but discharge persisted and a bronchocutaneous fistula was said to develop. In the next year a thoracoplastic operation was performed in which the 6th to the 10th ribs inclusive were resected on the right side anterolaterally. As no regeneration took place subsequently

the periosteum was presumably also resected or destroyed. No reduction in the amount of discharge followed this procedure.

ON ADMISSION.—She was a thin nervous underdeveloped girl. There was a sinus in the lower right chest in the anterior axillary line surrounded by a wide area of excoriated skin, and from it came a fairly profuse thin purulent discharge. The chest wall in the area was not rigid and its movements on respiration were paradoxical. The 5th to 1st ribs above were raised anteriorly as compared with the opposite side, exaggerating the asymmetry of the thorax. Radiography showed a sharp upper dorsal scoliosis (*Fig.* 68). Lipiodol in the sinus showed a cavity in the axillary line lying against the mediastinum (*Fig.* 69). A bronchogram showed normal filling (*Fig.* 70). (It may here be interpolated that all the data necessary for a correct diagnosis were now present, but that their significance was ignored and the previous diagnosis of empyema, complicated by a rather destructive operation, accepted.)

FIG. 69.—Lateral view of the cyst filled with lipiodol.

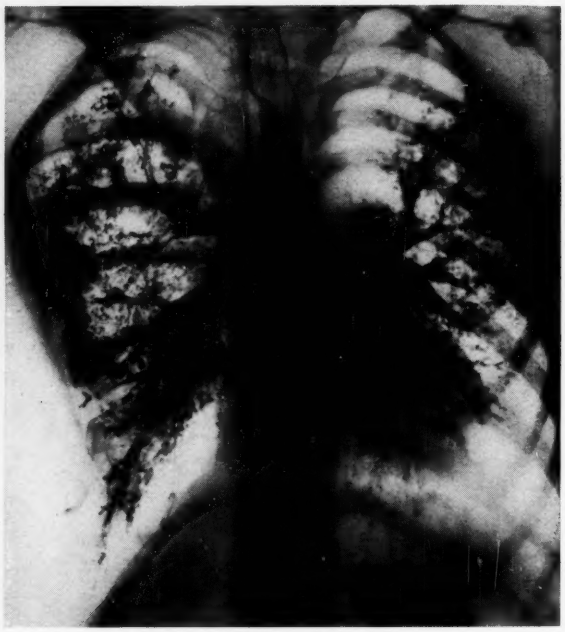


FIG. 70.—Normal bronchogram, 1935.

TREATMENT AND PROGRESS.—It was thought that a posterior subperiosteal thoracoplasty might serve the double purpose of correcting the grave deformity of the upper chest and reducing the size of the empyema. This was accordingly done in two stages from below upwards and completed by November, 1936. In between these stages closed drainage was established for several weeks. It was observed throughout the child's illness that operative procedures of every kind were tolerated very badly, producing shock at the time and a post-operative rise of pulse-rate which took a long time to return to normal. In consequence the subsequent operative procedures were hurried and often had to be concluded quickly.

From December, 1936, she was at home without treatment until re-admitted in March, 1938, when she was in a sorry plight. There was a severe scoliosis making an obvious deformity on standing. The skin excoriation was worse, and the child, although puberty was starting, was underdeveloped and sickly.

Postural treatment corrected the scoliosis (although without effect on the X-ray appearance of the spine) and in August, 1938, she stood quite straight.

Meanwhile two attempts had been made, in April and May, 1938, to collapse the cavity by approximating its 'pleural' walls, i.e., by stripping the parietal pleura from the bony cage and packing external to it. These procedures were naturally of no avail, but it was noted at the time that the 'parietal pleura' in parts stripped with unusual ease.

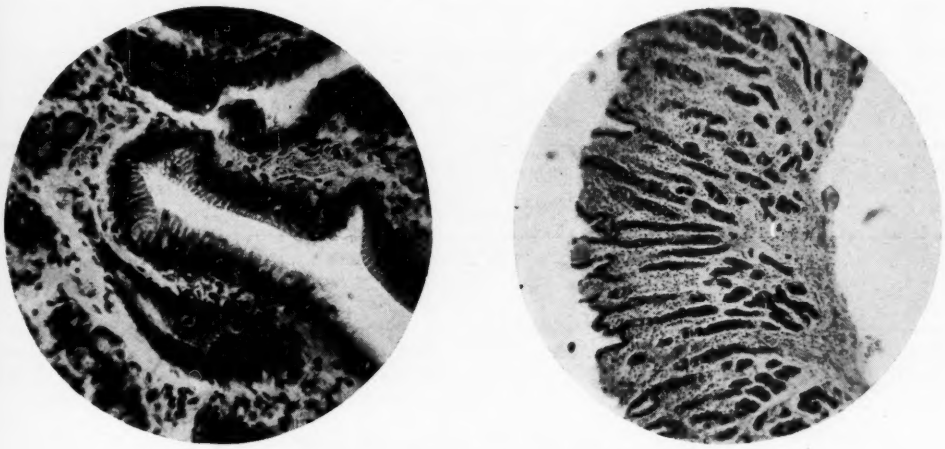
After a further period of convalescence, she was re-admitted to St. George's in September, 1938. The general condition was greatly improved, but the cavity, although smaller than in 1936, was still present. The skin was still severely excoriated round the discharging sinus.

At this time I suddenly realized we were dealing with a cyst rather than an empyema.

My colleague at the Royal Chest Hospital, Mr. J. B. Hunter, saw the patient with me and agreed that it was probably a cyst and that an attempt should be made to excise it.

This was done in October, 1938. Under a general anæsthetic the sinus opening was enlarged, and by a mixture of blunt and sharp dissection the lining membrane of the cavity was removed. It was very adherent and in the course of the dissection the aorta, œsophagus, pericardium, and superior vena cava narrowly escaped damage. Bleeding was not severe, but the patient's condition became very poor when all except the upper dome of the cavity had been freed. This was possibly due to the heavy traction necessary to drag this part into the operation field. Accordingly the free parts were excised and the remnant was treated with coagulation diathermy current. The cavity was lightly packed.

The patient not only survived, but almost immediately started the improvement which proceeded steadily to complete healing early in 1939. The excoriation of the skin rapidly



FIGS. 71, 72.—Part of lining of cyst under high and low power.

disappeared; the lung expanded, and the final stages of healing were by normal granulation of a superficial cavity. There was great improvement in the general health and physique, which has since been maintained.

The excised wall was sent to Dr. John Taylor for microscopical examination. The result was startling. I was sent for hurriedly to the Pathological Laboratory and accused of having removed a large portion of the stomach in error—an alarm which the position of the cyst on the right side and the child's already happy condition contradicted. The microphotographs of the section (*Figs.* 71, 72) will explain this histological diagnosis, as the mucosal lining resembles that of the normal stomach very closely.

The cause of the excoriation of the skin was now obvious. It was similar to that found surrounding many cæcostomy openings.

DISCUSSION

I have been able to find records of 12 similar or relevant cases. The salient features of these are set out in *Table I.* In addition to these cases, Brass reports 3 cases in each of which at post-mortem examination cysts in the right side of the chest were associated with small intra-abdominal cysts. The subjects were infants who were stillborn or died immediately after birth, and the cysts were lined with intestinal mucosa. These cases were reported by Roth, Henning-Leuss, and Schmincke, respectively.

Table I.—Cases fr[om] Lite[rature]

Author	Case				
	Age	Sex	Symptoms	Treatment	Result
Stahelin and Burckhardt, 1909	9 mth.	F	Operation for spina bifida. Death from meningitis. Cyst discovered post mortem	—	—
Mixter and Clifford, 1929	22 mth.	M	Pneumonia and (?) empyema	Two-stage operation. Packing, followed by excision	Recover
	7 wk.	M	Pain on feeding. Radiograph showed "pneumonia"	Attempted removal	Died
	3 mth.	F	Cyanosis. Inhaled foreign body (?)	Bronchoscopy	Died
Entz and Orosz, 1930	11 mth.	M	Malnutrition. Cyst discovered in right hemithorax	Aspiration followed by marsupialization	Died
Fischer, 1930	6 mth.	F	Right-sided pleural effusion. Sterile mucinous and blood-stained fluid	Tapped	Died
Black and Benjamin, 1936	4½ mth.	M	Abdominal symptoms. Radiograph showed shadow in left chest	None	Died
Boss, 1937	3 yr.	M	Hæmoptysis. Radiograph, cyst (?)	Two-stage operation	Died
Brass, 1937	—	M	Post-mortem on premature infant	None	Died
Guillery, 1937	3 mth.	?	(?) Congenital disease of heart; post-mortem examination	None	Died
Seydl, 1938	3½ mth.	F	Cough and hæmoptysis. Radiograph, shadow near right	None	Died
Smith, 1930	13 mth.	M	Pneumonia, (?) fluid	Aspiration	Died
Author's case	3 yr.	F	"Pneumonia and empyema". Chronic sinus. Excoriation of skin	Various plastic operations. Excision after eight years	Recover

SES FR LITERATURE

Result	Pathological Findings		General Remarks
	Macroscopical	Microscopical	
—	st size of gooseberry attached , but not communicating with, ght side of œsophagus	Wall of cyst epithelial, showing all features of gastric and œsophageal mucosa	Gastric cyst on right of mediastinum
Recover	tropleural cyst on right side	Typical structure of stomach	Gastric cyst on right
Died	rge multilocular cyst behind achea and œsophagus, extending up behind apices of both ngs	Typical gastro-intestinal structure	Gastro-intestinal cyst on right and left
Died	st at bifurcation of trachea, ut not connected with it or ronchi	Typical bronchial structure	Bronchial cyst in midline
Died	st attached to posterior mediastinum on right side	Typical gastric structure	Gastric cyst on right
Died	st behind right lung	Typical of pyloric mucosa and gastric wall	Gastric cyst on right
Died	Cyst behind left pleura and assing through a deficiency in e diaphragm intra-abdominally Cyst in abdomen containing erforated peptic ulcer	(*a*) Very little epithelium but other layers typical of stomach wall (*b*) Similar, but with typical gastric mucosa	Gastric cyst on left. Intra-abdominal gastric cyst with perforated ulcer
Died	st right side, attached to osterior mediastinum. Peptic lcer perforating lower lobe of ght lung	Typical gastric mucosa	Gastric cyst on right with perforated peptic ulcer
Died	st in right side of thorax ttached loosely to posterior ediastinum, supplied by intercostal arteries and vagus nerves	Typical small intestine (all layers)	Intestinal cyst on right side
Died	st in mediastinum lying on 3rd nd 5th dorsal vertebræ. Second yst in spinal canal behind 5th orsal vertebræ	In part tracheal structure, in part œsophageal	Mediastinal cyst, tracheal and œsophageal
Died	st behind right pleura with eptic ulcer perforating into ght lung	Typical mucosa of stomach	Gastric cyst on right with perforated peptic ulcer
Died	st on right side and in mediastinum; 5 × 1½ in.	Ciliated respiratory epithelium and gastric mucosa	Gastric cyst on right side
Recover	st on right side attached to ediastinum. No connexion ith œsophagus	Typical gastric mucosa	Gastric cyst on right side

There are several points to be noted in the table. The first is that most of the cysts (9) were found in the right hemithorax, only 3 being median in position, and only 1 on the left. In most of the cases symptoms were produced very early in life, there being only 1 other beside my own ease (i.e., that of Boss) in which the child was as old as 3 years. The symptoms were variable, and, as might be expected in such young subjects, diagnosis was difficult. In the case reported by Black and Benjamin and in those quoted by Brass there were intra-abdominal cysts coincident with a thoracic one. In the case of Entz and Orosz and in my own there was digestion of the skin; in two instances (Boss and Seydl) a peptic ulcer was found perforating into the lung and causing hæmoptysis; and the abdominal cyst reported by Black and Benjamin also contained a perforated peptic ulcer. In all these the digestive juice must have been active, as it was in my case. (It may be said in passing that any view as to the causation of gastric ulcers seems incomplete unless it explains the presence of these ulcers in a closed cyst.) In no case, unfortunately including my own, was an analysis of the fluid made for digestive enzymes.

Many of the authors produce hypotheses to account for these intestinal formations. In the main two explanations are put forward: (1) That they are sequestered from the foregut in the course of development; (2) That they are derived from the vitello-intestinal duct. I do not propose to go far in this matter, but there are reasons for accepting the first hypothesis. In the case of Stahelin and Burckhardt the cyst showed microscopical features of both gastric and œsophageal mucosa, while in Mixter and Clifford's third case the cysts showed a bronchial structure. Although in none was there any direct connexion with œsophagus or trachea, they all appeared to arise from the posterior mediastinum. Many cysts showed a double muscular layer typical of the stomach, and in the case described by Brass a nerve-supply from the vagus could also be demonstrated. These findings seem all to point to an origin from the foregut rather than from the vitello-intestinal duct.

My interest in recording this case, however, is not morphological, but clinical. Cysts lined with intestinal mucosa (commonly gastric in type) do occur, though rarely, in the thorax, and more frequently on the right side. It seems possible that their exact nature may be diagnosed before operation by analysis of fluid obtained by aspiration.

The condition has, in most cases, proved fatal in infancy. In the only recorded cases of recovery the cyst was removed in two or more stages, the first of which produced marsupialization.

There seems, however, no prima facie reason why one-stage removal should not be successful.

REFERENCES

BLACK, R. A., and BENJAMIN, E. L., "Enterogenous Abnormalities; Cysts and Diverticula", *Amer. Jour. Dis. Child.*, 1936, **51**, 1126.

BOSS, C., "Kongenitale, mit Magenschleimhaut ausgekleidete Mediastinalcyste mit in die Lunge penetrierendem chronischem Ulcus pepticum", *Virchows Arch.*, 1937, **300**, 166.

BRASS, K., "Ueber einen Fall von intrathorakalem Enterocystom; zugleich ein Beitrag zur Pathogenese, *Frankfurt. Zeits. f. Pathol.*, 1936, **50**, 26.

ENTZ, B., and OROSZ, D., "Mucous Membrane Cysts of the Stomach, Intestines, and Thoracic Cavity", *Gyógyászat*, 1930, **69**, 102, 123, 149.

ENTZ, B., and OROSZ, D., "Ueber die intrathorakalen Zystenbildungen", *Frankfurt. Zeits. f. Pathol.*, 1930, **40**, 229.

FISCHER, quoted by SEYDL.
GUILLERY, H., "Eine in die Wirbelsaule, eingewachsene mediastinale Zyste (Vorderdarmzyste)", *Zentralb. f. allg. Pathol. u. pathol. Anat.*, 1937, **69**, 49.
MIXTER, C. G., and CLIFFORD, S. H., "Congenital Mediastinal Cysts of Gastrogenic and Bronchogenic Origin", *Ann. of Surg.*, 1929, **90**, 714.
SEYDL, G. N., "Eine kongenitale Magenwandcyste im Mediastinalraum mit in die Lunge perforiertem Ulcus pepticum", *Frankfurt. Zeits. f. Pathol.*, 1938, **52**, 346.
SMITH, R. E., *Guy's Hosp. Rep.*, 1930, **80**, 466.
STAHELIN and BURCKHARDT, quoted by BOSS.

EXCISION OF THE BODY OF THE PANCREAS

PATIENT WELL FOR THIRTEEN YEARS: DEATH FROM OESOPHAGEAL CARCINOMA

BY W. SAMPSON HANDLEY, LONDON

MRS. S., then aged 60, was seen by me with Dr. Joseph White, of Clapham, on Feb. 27, 1923. A spare patient, with a mobile right kidney and slight hyperthyroidism, she complained of severe epigastric pain of two years' duration with tenderness of recent origin, accompanied by nausea and not definitely related to food. Dr. White had detected a small deep mobile lump, of recent origin and very tender, perhaps 2 in. in diameter, and situated just above and to the right of the umbilicus.

An exploratory operation was done early in March, 1933, through a high right paramedian incision. The head of the pancreas was normal, the body was occupied by a hard irregular granular thickening. The pancreas itself was unusually mobile, no doubt as a part of a general tendency to enteroptosis. It was exposed by an incision through the lesser omentum and the posterior layer of the lesser sac. An incision into the gland substance showed calcareous deposit, and a stone about $\frac{1}{4}$ in. in diameter was removed. It was evident, however, that the calcareous material did not entirely lie in the ducts, but was diffused in the substance of the gland. Several cysts, the largest about 1 in. in diameter, were also present.

There was no difficulty in stripping off the gland from the splenic vein and the other surrounding structures, and it was decided to excise the body and tail of the gland. A clamp, subsequently replaced by a ligature, was placed vertically between the body and the head, and the gland cut across with scissors. An attempt was then made to remove the tail along with the body, but as the hilum of the spleen was approached alarming oozing occurred. The tail was therefore clamped off, tied, and left in situ, and the body was removed. The operation was terminated by introducing a vaseline gauze pack to check persistent oozing about the tail. A small drainage tube was left in. At the end of the operation, which lasted an hour, the pulse was 120 and the general condition only fairly satisfactory.

The vaseline gauze was removed on the fifth day, and a little clear fluid escaped following its removal. On the tenth day some sloughs escaped from the sinus, probably owing to a necrotic pancreatitis of the residual portion of the tail, the ducts of which were obstructed by the ligature of the tail. Several calcareous fragments also escaped, and at this time there was some pyrexia, but epigastric pain had entirely gone and has not since recurred. After closing in 1923 the sinus reopened and discharged some pus. By December, 1923, it had permanently closed. At no time has there been any sugar in the urine.

A hard rounded lump in the posterior part of the right lobe of the thyroid has been diagnosed as a calcified adenoma. The possibility of a parathyroid tumour was considered and rejected.

Apart from her slight hyperthyroidism this patient remained free from symptoms, and was able to eat anything without discomfort, for thirteen years, except that in September, 1933, she had a serious and unexplained duodenal hæmorrhage, for which she underwent medical treatment by Dr. White.

In February, 1936, she began to complain of dysphagia, and X-ray and œsophagoscopic examination disclosed a primary carcinoma of the œsophagus. On

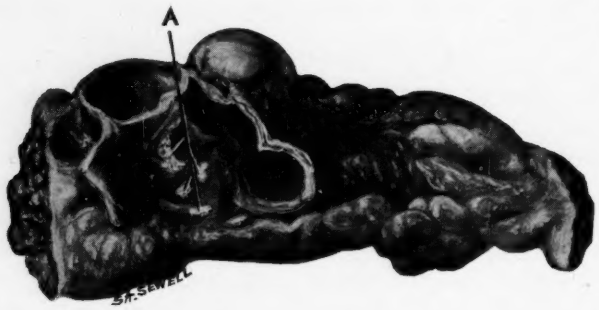


FIG. 73.—Drawing of the body of the pancreas after removal. Several small cysts are present, and at A a calculus can be seen in situ in one of the ducts. Right and left respectively are seen the planes of section separating the body from the head and tail, which remained in situ. (*Natural size.*)

two occasions this was treated by radon insertions by Mr. F. J. Cleminson. Death occurred in November, 1936.

THE SPECIMEN.—The accompanying drawing, of natural size, shows the body of the pancreas after removal (*Fig.* 73).

A section of a non-calcified area of the excised pancreas showed a system of spaces lined by flattened epithelium lying in dense cicatricial fibrous tissue. The secreting acini were destroyed in this area, but at its margin intact islets of Langhans and normal secreting acini could be seen. The condition appeared to be an old chronic pancreatitis probably initiated by the formation of calculi in some of the larger ducts.

DISAPPEARANCE OF AN EXTRATHORACIC ANEURYSM

BY G. R. McROBERT AND D. GOVINDA REDDY

FROM THE UNIT OF THE PROFESSOR OF MEDICINE, GENERAL HOSPITAL, MADRAS

THE interest in this case lies in the practical disappearance of a large extrathoracic swelling with expansile pulsation connected with an intrathoracic aneurysm.

HISTORY.—The patient was an Anglo-Indian male, 28 years old, admitted to the Madras General Hospital on January 10, 1936, complaining of swelling in the chest, with severe pain and dyspnœa. He gave a history of a blow by a cricket ball on the chest two years before, but the swelling had appeared only three months ago.

ON EXAMINATION.—A pulsating tumour was found on the anterior aspect of the left side of the thoracic wall, extending from the suprasternal notch to the

4th rib, about 3 in. high in the centre and approximately 5 in. in diameter (*Fig.* 74). There was easily demonstrable systolic expansile pulsation, with a systolic murmur on auscultation.

Examination of the chest revealed typical signs of intrathoracic aneurysm (*Fig.* 75).

There was no enlargement of the left ventricle, no alteration in the voice or pupils, but the blood-pressure was 10 mm. lower on the left side than on the right. The Wassermann reaction was strongly positive.

Careful palpation failed to reveal any gap in the ribs, and the nature of the swelling rendered X-ray examination of the ribs unsatisfactory, but no doubt was felt in the minds of many physicians and surgeons who examined this case at

FIG. 74.—Photograph showing the swelling on the thoracic wall at the time of admission.

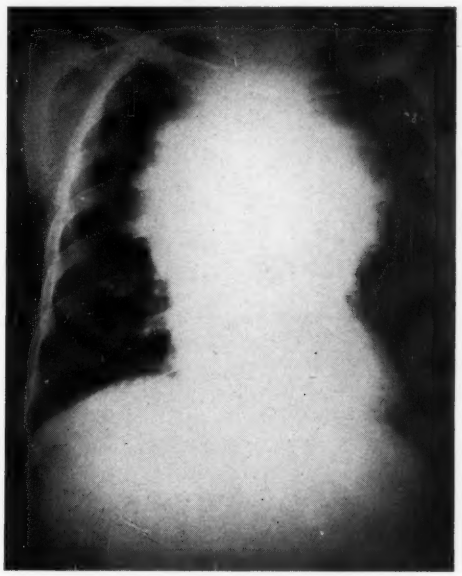


FIG. 75.—Radiograph showing typical signs of intrathoracic aneurysm.

hospital clinical meetings and at clinical societies, that the swelling under the skin represented part of the sac of an aortic aneurysm.

PROGRESS.—The patient was confined to bed, and iodides and mercury were administered, but owing to rapid increase in the severity of the pain and growth of the tumour morphine had to be resorted to several times a day.

In May, 1936, rupture was expected daily. At this time the senior author proceeded on leave to England. On his return in October the patient was still in the ward, and the tumour had greatly diminished and scarcely exceeded a hen's egg in size.

The patient left hospital against advice in November, 1936, and took up cycling and light work.

He was re-admitted for short periods from time to time during 1938 and 1939, and frequent observations during that time confirmed the steady process of retrogression of the extrathoracic swelling (*Fig.* 76). During 1939 he was admitted

on several occasions for dyspnœa and cough. There was increasing involvement of the left recurrent laryngeal nerve. In October, 1939, he was admitted with signs of cardiac failure and died of failure with venous congestion with regular rhythm. There was no rupture of the aneurysm and no embolism.

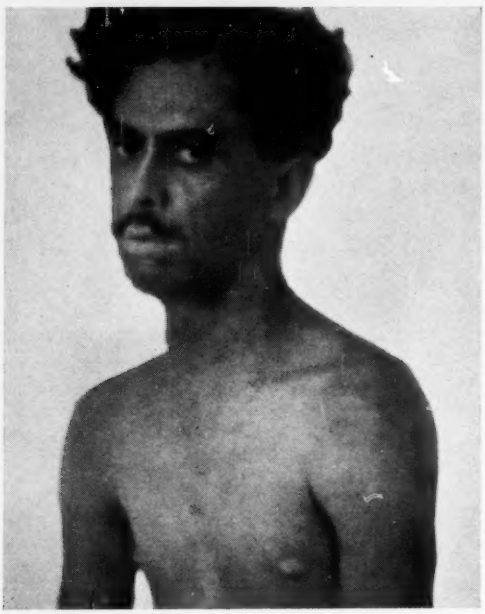


FIG. 76.—Photograph showing the extent of retrogression of the swelling.

On his final admission the former extrathoracic tumour was represented by a hard nodular swelling about the size of a small marble between the second and third ribs.

AT AUTOPSY.—Post-mortem examination revealed a saccular aneurysm 6 in. in diameter, communicating with the aortic arch at its commencement by an opening $1\frac{1}{4}$ in. in diameter. It contained a laminated clot partially projecting from the sac into the aortic lumen (*Fig.* 77). The sac had a dense fibrosed wall firmly adherent to the surrounding structures. It had partially eroded the manubrium sterni and had nearly completely eroded the inner ends of the second and third ribs on the left

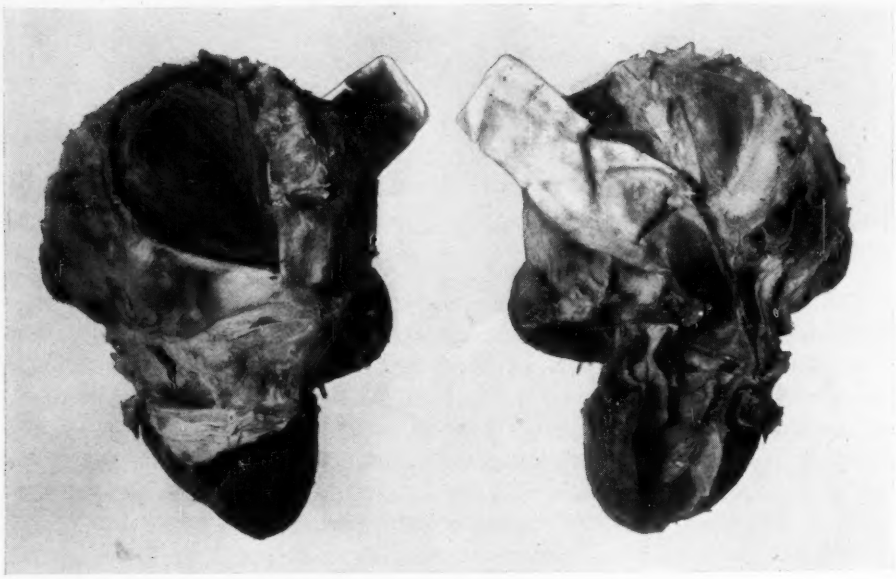


FIG. 77.—Specimen of aneurysm removed post mortem.

side. There was, however, except for an organized fibrosed lump between the 2nd and 3rd ribs, no signs of the sac which had contained the extra-thoracic

portion of the aneurysm which had disappeared, and it is this feature of the case to which attention is drawn.

Comment.—The presence of the extrathoracic portion of the aneurysm is not in doubt, and its disappearance is a pathological curiosity which can only be accounted for by organization and retraction of the herniated portion of the aneurysm over a period of three years.

It was at one time thought that the disappearance of the tumour could have been accounted for if the original swelling had been due to a small rupture of the aneurysm between the 2nd and 3rd ribs, but in such a case the swelling would not have been expansile and signs of old blood-clot would have been found at post-mortem examination.

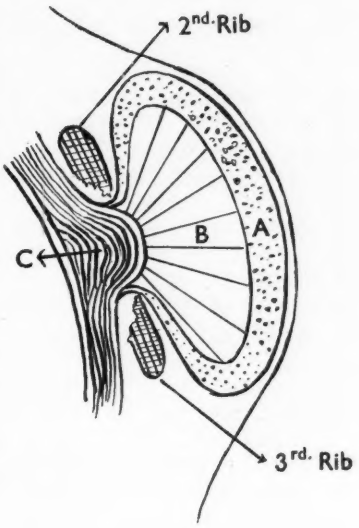


FIG. 78.—Diagrammatic representation in vertical section of the series of events which accounted for the disappearance of the aneurysm. A, Original sac containing fluid blood projecting between ribs; B, Blood clotted, serum absorbed; C, Sac completely shrunken and fibrosed after three years.

The diagram (*Fig.* 78) represents in vertical section the series of events which probably accounted for this remarkable phenomenon.

We are indebted to Professor P. Ramachandra Rao, Professor of Pathology, Madras Medical College, for the post-mortem findings.

REVIEWS AND NOTICES OF BOOKS

The Surgery of the Alimentary Tract. By Sir HUGH DEVINE, M.S., F.R.A.C.S., F.A.C.S., Formerly Senior Surgeon, St. Vincent's Hospital Clinical School, Melbourne, and other Stewart Lecturer in Surgery, Melbourne University; President, Royal Australasian College of Surgeons; etc. $8\frac{7}{8} \times 6$ in. Pp. 1046 + xvi, with 690 illustrations, some in colour. 1940. Bristol: John Wright & Sons Ltd. 63s. net.

THIS is a remarkable book and one of outstanding merit. It will be most useful, first, to give a brief account of its contents and their arrangement before commenting on the special features of the book.

Part I (237 pages) is devoted to the diagnosis of dyspepsia, which the author admits to having been his own greatest weakness in abdominal surgery. A great many different so-called patterns of dyspepsia are described. The whole of this section is based on a careful foundation of physiology, and a great deal of importance is attached to the fact of dyspepsia being caused by the filling or emptying of the stomach. The first chapters deal with dyspepsia in the œsophagus, but the treatment is only given for cardiospasm, and that of malignant disease or stricture is omitted. There is a special section devoted to radiography and gastroscopy of the upper part of the alimentary tract.

The second part of the book is concerned with the surgical treatment of the diseases giving rise to dyspepsia, including those of the liver, gall-bladder, pancreas, and spleen. The technique is described in great detail, and such matters as the tying of knots, the use of the needle, and suturing, have great prominence given to them. In the general conduct of abdominal operations the author makes out a good case for the use of a special mechanical retractor, consisting of a square metal frame, on the edges of which various retractors may be attached, permitting clear inspection of the abdominal contents. By means of this device the abdominal wall can be lifted up so as to give a good view of the interior of the abdomen, and it is claimed that by its use all operations can be done inside the abdomen instead of lifting or dragging the viscera out on to the parietes. The description of surgical procedure is followed by an account of post-operative complications and their treatment. In discussing blood transfusion the author makes the comment that current methods are legion, but this does not prevent him from recommending another new method depending on the use of an apparatus of special construction (Neo-Athrombit). In this it is claimed that whole and uncitrated blood can be transferred from the donor to the recipient.

The third part concerns the surgical treatment of a perforation of the hollow viscus and of intestinal obstruction.

The fourth part deals with the surgery of the appendix and of the large bowel. In regard to appendicitis the author holds that deaths in acute appendicitis often result from the failure to recognize unusual syndromes, and therefore special attention is directed to these anomalous cases. The chapters on the large intestine, colon, and rectum mark the most outstanding part of the book, because in them the author shows how he has learned by practical experience to overcome many difficulties, so as to make safe what was formerly a hazardous procedure. The readers of this JOURNAL will be familiar with many of the author's methods of defunctioning the colon or the rectum before performing radical operations on these structures.

In a book of this size it is not possible to do more than comment on general methods and arrangements. The first great merit possessed by it is its originality; from first to last the author gives nothing but his own personal experience and his own convictions. But this does not imply that he has not made himself fully conversant with current teaching and literature, to which he refers freely. Associated with the personal character of the book is the quotation of a great many case records. The choice of illustrations and the way in which they are reproduced are excellent. The chief fault which the book has is its over-elaboration, and we confess that we find this confusing rather than helpful. But there can be no doubt that the book represents an account of the life work of a great and experienced surgeon and teacher, and its appearance does credit alike, both to the author and the publisher.

Minor Surgery. By R. J. McNeill Love, M.S. (Lond.), F.R.C.S. (Eng.), Surgeon, Royal Northern and Metropolitan Hospitals; etc. $7\frac{1}{4} \times 4\frac{7}{8}$ in. Pp. 379 + viii, with 155 illustrations. 1940. London: H. K. Lewis & Co. Ltd. 12s. 6d. net.

Minor surgery, as the author states in his preface, is difficult to define. There are no natural or artificial boundaries between it and so-called major surgery. The present volume "is intended to be a guide to hospital residents and an aid to practitioners who from choice or necessity feel called to deal with minor surgical problems or common surgical emergencies".

It is from that point of view then that the book should be considered in order to justify its appearance, but throughout there is an absence of insistence upon principles, and a predilection to supply 'tips' and 'short cuts' to diagnosis and treatment.

The treatment of scalds and burns is sketchy, and dismissed in little more than one and a half pages, yet these cases are very common and give rise to grave anxiety. Surely removal of a foreign body from the ear of an anæsthetized child would be better done under direct vision rather than blindly "dislodged with the aid of a blunt hook", and there should be better methods of checking epistaxis than by "sniffing cold air up the nose".

The aim of all surgical text-books, either of the minor or major category, should be to enable the reader, whether hospital resident or practitioner surgeon, to acquire surgical judgement. This could have been well exemplified in dealing with the treatment of varicose veins, yet no attempt is made to indicate which type benefit by injection alone and which need more extensive operative treatment. The electric cautery is advocated for dealing with multiple infective warts, but no mention is made of removing the cause.

Proper stress is laid upon surgical judgement in dealing with the treatment of infections of the hand. The importance of locating the site of infection, and choosing the appropriate moment for and the site of incision, is rightly insisted upon. No mention, however, is made of the importance of such primary treatment as absolute *rest* to the part, and how this is to be attained; but this, with other prophylactic methods, such as hyperæmia, may render operation unnecessary.

The section on genito-urinary surgery is good and just what the hospital resident requires, and in subsequent editions might be taken as a model for the rest of the book.

The section on fractures lacks an insistence on principles in diagnosis and treatment; it is rather of the nature of a pocket compendium.

The author has had the impossible task of fitting his subject into the limited space available. Should a fractured os calcis "be left a week before attempting reduction", and gas gangrene be dismissed in a short paragraph ending with the sentence, "Incisions into the affected part may be required and occasionally amputation"? There is no mention of gas gangrene in the index nor of tetanus, which is not even referred to in the section on wounds.

The whole book leaves an impression of haste and hurry; perhaps it reflects the feelings of many nine months ago when *Blitzkrieg* was almost a household word.

A Synopsis of Surgery. By Ernest W. Hey Groves, M.S., M.D., B.Sc. (Lond.), F.R.C.S. (Eng.), Consulting Surgeon to the Bristol General and Municipal Hospitals, and to the Treloar Cripples' Hospital, Alton, Hants; etc. Eleventh edition. $7\frac{1}{4} \times 4\frac{7}{8}$ in. Pp. 714 + viii, with 195 illustrations and 13 coloured plates. 1940. Bristol: John Wright & Sons Ltd. 17s. 6d. net.

This book is such an old friend that we are inclined to say that we know its merits and its failings almost without looking at it again. If, however, one takes the trouble to read carefully through each new edition the sense of wonder at the astonishing amount of information and good advice which has been compressed into such small bulk is continually renewed, and one puts the book down with the conviction that its popularity has been well merited and is justly maintained. The adverse criticism is that it has been written more as a short cut to success in examinations than a guide to surgical practice, but from the systematic way in which the material is set out the reader may learn to become methodical in his everyday work—an important factor making for success in practice as well as in examinations.

Much care and thought has been devoted to bringing the present edition up to date, almost every chapter including references to recent work, though the chief alterations and additions are to be found in the sections describing the newer developments in the treatment

of fractures. This portion of the work, and that on joint diseases, are well illustrated. The chapters on the genito-urinary system require further revision, and it is questionable whether some of the sections dealing almost entirely with pathology are needed in a book of this type, since it is difficult for a surgeon to write with authority on the recent advances in pathology, for which the student has come to rely on special text-books.

The short section on surface anatomy at the end of the book is most valuable and is clearly illustrated; and the inclusion of a description of some of the newer operations for cleft palate is noteworthy. Intracranial surgery is dealt with briefly but comprehensively, and in this, as well as in other sections, Mr. Hey Groves has had the benefit of the assistance of Mr. W. Willway.

The Early Diagnosis of the Acute Abdomen. By ZACHARY COPE, B.A., M.D., M.S. (Lond.), F.R.C.S. (Eng.), Surgeon to St. Mary's Hospital, Paddington; Senior Surgeon to the Bolingbroke Hospital, Wandsworth Common; Late Hunterian Professor and Arris and Gale Lecturer, Royal College of Surgeons. Eighth edition. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. 257 + xv, with 36 illustrations. 1940. Oxford University Press. (London: Humphrey Milford.) 10s. 6d. net.

THIS book is so well known that the appearance of another edition calls for little comment. It is readable, accurate, clear, and helpful, emphatically the best book of its type. The author himself makes no particular new claim for his eighth edition. He promises minor verbal changes and three more X-ray photographs. He claims that the reception accorded to the book has shown that it has met a need and that no major alteration is, therefore, necessary. With this opinion the reader will concur. Nothing remains but to recommend any surgeon who is unfamiliar with the book to buy it.

Demonstrations of Physical Signs in Clinical Surgery. By HAMILTON BAILEY, F.R.C.S (Eng.), Surgeon, Royal Northern Hospital, London; Surgeon and Urologist, Essex County Council; Surgeon, Italian Hospital; Consulting Surgeon, Clacton Hospital and the County Hospital, Chatham; External Examiner in Surgery, University of Bristol. Seventh Edition, revised. 9 × 6 in. Pp. 310 + xii, with 377 illustrations, some of which are in colour. 1940. Bristol: John Wright & Sons Ltd. 21s. net.

THIS book is so popular and well known that the appearance of the seventh edition does not call for much comment. Every medical student should have a copy of this book. The difference between the seventh and earlier editions is not striking, and those who have earlier copies need not feel them out-dated. The author claims new figures and historical footnotes as the new features of this edition.

Two minor criticisms emerge. There is no reference to palpation of the carotid vessels in cases of goitre. This is a valuable differential test in cases of suspected malignant enlargement of the thyroid. There is no mention of the need for relaxation of the quadriceps muscle when testing for abnormal mobility in the knee-joint; it is essential to have the muscle relaxed to detect slight degrees of abnormal mobility. In general, the book is excellent and dependable; the student who masters the physical signs set forth will know how to examine his patients with confidence and accuracy.

Synopsis of Surgical Anatomy. By ALEXANDER LEE MCGREGOR, M.Ch. Edin., F.R.C.S. Eng., Lecturer on Surgical Anatomy, University of the Witwatersrand; Assistant Surgeon, Johannesburg General Hospital. With a Foreword by Sir HAROLD J. STILES, K.B.E., F.R.C.S. Edin. Fourth edition. $7\frac{1}{4} \times 4\frac{7}{8}$ in. Pp.664 + xx, with 648 figures. 1939. Bristol: John Wright & Sons Ltd. 17s. 6d. net.

THIS book, which has reached its fourth edition since it was first published in 1932, has fully attained the position we predicted for it when it first appeared. It is written by a keen surgeon with a sound knowledge of anatomy. More than half the book is concerned with the anatomy of the abnormal. This includes not only congenital defects, but such various subjects as bodily habitus, stiff joints, limps, the anatomical basis for clinical tests, and the anatomy of certain surgical procedures and of surgical approach. The wealth and clarity of the line

drawings are of great value. Considering how completely the author has dealt with the anatomy of many modern surgical problems, it is surprising that those relating to the intervertebral discs are hardly mentioned either with the section on normal anatomy or that on backache. We hope that these will be included in future editions.

Surface Anatomy. By W. E. ROBERTS, M.R.C.S., L.R.C.P., Honorary Demonstrator of Anatomy, University of Sydney. With a Foreword by A. N. BURKITT, M.B., B.Sc., Professor of Anatomy, University of Sydney. 9 × 5¾ in. Pp. 93 + x, with 40 plates. 1939. London and Sydney: Angus & Robertson Ltd. 7s. 6d. net.

THIS little book is a model of clarity and brevity. It consists almost entirely of full-page photographs of the living subject, with the underlying structures marked in. Opposite each plate is a complete descriptive text of explanation. These features make it valuable for study and reference.

Tuberculosis of Bone and Joint. By G. R. GIRDLESTONE, M.A., B.M. (Oxon.), F.R.C.S. (Eng.), Nuffield Professor of Orthopædic Surgery; Fellow of New College, Oxford; Hon. Surgeon and Hon. Clinical Director, Wingfield-Morris Orthopædic Hospital, Oxford. 9½ × 6⅝ in. Pp. 265 + xii, with 161 illustrations. 1940. Oxford University Press. London: Humphrey Milford. 30s. net.

THIS monograph covers the whole field of joint tuberculosis, but there is little mention of bony lesions situated at a distance from joints. It is the fruit of an experience of more than twenty years' work at the Wingfield-Morris Orthopædic Hospital. It is a testament to the thought and care which Mr. Girdlestone has devoted to these problems, and to the originality and enthusiasm with which he has leavened the older and more conservative outlook.

The opening chapters deal for the most part admirably with the general aspects of the disease, and on the whole fairly represent contemporary British practice. In subsequent chapters each joint is dealt with in detail, and a separate chapter is devoted to Pott's paraplegia. A very useful appendix gives details of apparatus and of occupational therapy and rehabilitation for tuberculous patients.

In the present monograph too much emphasis is laid throughout on the value of operative treatment. All experienced surgeons agree that bony ankylosis is the most desirable end-result of tuberculous arthritis, and that it can only be achieved by an arthrodesis, preferably extra-articular for most joints, when the disease has soundly healed as the result of a prolonged period of conservative treatment. But bony ankylosis is by no means an absolute necessity in order to achieve a safe and durable end-result—a fact proven over and over again by the many excellent results of H. O. Thomas and Sir Robert Jones, obtained by conservative treatment only. While stressing again and again the paramount importance of the true conception of a tuberculous bone or joint lesion as being merely part of a highly dangerous general disease, the author, in dealing with individual joints in adults, tends to depart from this outlook and to urge the need for early or radical operations. And his justification for these is not always sound, e.g., it cannot be agreed that adults *commonly* deteriorate as a result of prolonged recumbency, and such a statement must be regarded as the flimsiest of pretexts for early operation. There may indeed be a case for wide and radical excision of areas in which the predominant factors are multiple sinuses and secondary infection of very long standing in a patient in reasonable general health. But it is most difficult to share Mr. Girdlestone's faith in the possibility, feasibility, or logic of surgical excision of a large focus of active tuberculous disease in a patient already going downhill, apart from those lesions which permit of a rapidly performed shockless amputation.

Of very doubtful value is the clearing out of extra-articular foci where the joint is not obviously involved. A recent careful review of cases treated in another centre showed that such a procedure did no more than, if as much as, prolonged conservative treatment to prevent ultimate joint involvement. Again, recent investigations indicate that fusion plays no constantly beneficial role in the treatment of tuberculous sacro-iliac disease.

On Pott's paraplegia Mr. Girdlestone writes trenchantly and feelingly, though not altogether convincingly. After Seddon's and Butler's careful work on this subject in 1935 it is hardly fair to say that " no clear modern statement has been made of the indications for operative treatment and of the conditions necessary for its safe performance." All will agree

that there is a strong argument for early spinal decompression in *selected* cases. But the difficulty arises in the selection! The majority of paraplegias recover without operation, even in the presence of a tense paravertebral abscess, if the patient is adequately immobilized. So far it has usually been impossible to recognize the presence of a bony compressive factor (sequestrum, ridge, or dislocation), which, of course, would certainly be an indication for early operation. It may be that in this respect tomography will afford more help in the future.

Mr. Girdlestone describes clearly the technique of costo-transversectomy and laminectomy, and he rightly stresses that they are better not done at all unless carried out " in association with uninterrupted and adequate immobilization of the spine, before, during, and for months after the operation ". One of the best sections in the book is the description of the nursing of a paraplegic patient, though it is surprising that he does not mention Monroe's ' tidal wave drainage ' method in the treatment of bladder paralysis.

This book is an interesting and instructive account of the personal experience of one who has devoted a surgical lifetime to the difficult problems of bone and joint tuberculosis. It is full of valuable information and it emphasizes many important truths, but it cannot be said to represent fairly that balanced mixture of conservatism and radicalism which is the characteristic of the best contemporary British practice in this branch of the tuberculosis problem.

Handbook of Orthopædic Surgery. By ALFRED RIVES SHANDS, jun., B.A., M.D., Medical Director of the Nemours Foundation, Wilmington, Delaware; etc. In collaboration with RICHARD BEVERLY RANEY, B.A., M.D., Associate in Orthopædic Surgery, Duke University School of Medicine. Second edition. 9 × 6 in. Pp. 567, with 154 illustrations. 1940. London: Henry Kimpton. 21s. net.

JUST over two years ago Dr. A. R. Shands published a *Handbook of Orthopædic Surgery*, intended primarily for undergraduate students. It was not above the average in its class, but it had the merit of comparative brevity, and it was cheap. The illustrations were poor, but this fault has been adjusted in the second edition now in our hands. Unfortunately the text has not been improved correspondingly; the reader is lost in a maze of detailed information, and the guiding principles of the subject, the only part of orthopædic surgery that ought to be presented to the undergraduate, are nowhere expounded with the clarity that they merit. It is the duty of the teacher to dwell chiefly on what is positively known about the nature, diagnosis, and treatment of a disease or group of diseases, and the more obscure the disease the greater the need for simple honest statements—even if they involve a confession of our ignorance. Let us consider what Dr. Shands has to say about the treatment of chronic arthritis of the rheumatoid type: his treatment includes various kinds of food; cod-liver oil and ' haliver ' oil; wheat-germ and yeast preparations; salicylates; neocinchophen; iron, if there is anæmia; sometimes arsenic; sulphur, if there is a sulphur deficiency; gold salts, sometimes in conjunction with sulphur; " all forms of iodine preparations are of value "; sterile milk injections; typhoid vaccine; and, needless to say, hormones. Added to this there is the orthopædic treatment. All this information is useless to the student and of little value to the practitioner, because it does not tell the man actually treating the disease exactly what to do. An Elizabethan puritan in condemning football (the rough-and-tumble medieval variety) ended his tirade with these words: " Is this to do to another as we would wish another to do to us? God make us more careful over the bodies of our brethren ". It would be well for teachers to remember that they were once students, and to be more careful over the minds of those who learn from them—most of all when the teaching is committed to writing.

Cura Operatoria della Fratture del Collo del Femora. By V. PUTTI. $9\frac{5}{8} \times 6\frac{3}{4}$ in. Pp. 174, with 227 illustrations, some in colour. 1940. Bologna: L. Cappelli. L. 60.

A LAYMAN glancing through Professor Putti's book on the operative treatment of fractures of the neck of the femur remarked " this seems to be the engineer in the theatre ". He had noticed the use of testing-machines to discover the hold of a screw in the separated femoral head, in tension, compression, and torque. The surgeon will notice in addition the histological evidence of impaction, with minimal limits of aseptic necrosis and stimulation of callus formation.

Professor Putti holds that only consolidated bone is capable of withstanding the weight of the body in all positions, and does not rely upon his doubly-threaded bolt and nut to

withstand all the stresses that naturally may fall upon the femoral neck. He is a born mechanic and does not like nails, flanged or plain. In his hands, the repairing job is done with craftsmanship and artistry, and the results are very good, comparing them on equal terms with those of the popular method.

The book is, however, divided into two parts, the first dealing with the bolting method of treating recent fractures, and the second describing his routine method with 'old' injuries. When is a fracture no longer recent? It is not necessarily a question of days or weeks, but in part at least is dependent upon the damage done to the circulation in the fragments, and in consequence to the viability of the bone tissue. In some instances radiological evidence of early regressive and absorptive changes in the fragments is enough to put the case in the class not suitable for bolts; some of considerable standing, on the other hand, prove satisfactorily to receive and hold the screw thread. For the old-standing case, Putti prefers an osteotomy just above the lesser trochanter, preserving the attachment of the psoas to the distal fragment with great care. By this operation he obtains excellent functional results.

No method is exempt from certain troubles, and the author frankly describes his less successful efforts. The bolt disengages; or travels laterally in the yielding bone, permitting external rotation of the thigh; the placing is not always quite perfect; alinement has not always been precisely attained before the parts are drilled; but taking it all round, the series of cases he reports is just such a brilliant record as is expected from the Rizzoli.

The book is simply written, logically presented, clearly and effectively illustrated, well-documented, and well-printed. The bibliography is generous.

Diseases of the Foot. By EMIL D. W. HAUSER, M.S., M.D., Assistant Professor of Bone and Joint Surgery, Northwestern University Medical School; Attending Orthopædic Surgeon, Passavant Memorial Hospital, Chicago. With a Foreword by SUMNER L. KOCH, M.D. 9⅛ × 6 in. Pp. 472 + xv, with 173 illustrations, some in colour. 1939. Philadelphia and London: W. B. Saunders Co. 27s. 6d. net.

DR. SUMNER KOCH in the foreword puts forward the justification for this volume. Mr. Norman Lake's excellent treatise is accounted too brief, while Hohmann's *Fuss und Bein*, though fuller, is inaccessible to those not well versed in German.

The early chapters deal with anatomy, embryology, and physiology of the human foot. There is an interesting section, well illustrated, dealing with the development of the foot in different races according to the varying special functional demands, and another on the foot in the growing child which contains very useful advice. The subsequent twenty chapters are devoted to orthopædic conditions of the foot, but, in addition, affections of skin, nerves, and blood-vessels, which strictly might lie outside the sphere of the orthopædic surgeon, are dealt with. The last five chapters deal with the care of the feet during pregnancy and prolonged illness, local anæsthesia, the technique of plaster application, the technique of manipulation, and a full list of orthopædic appliances. The level of the book is uniformly high. Treatment is along sound lines and generally such as finds favour among orthopædic surgeons in this country, though it occasionally masquerades under names which may not be familiar. Adequate recognition is given to the work of Sir Robert Jones and to British orthopædic surgeons. Conservative methods are stressed. The reproductions of X-ray photographs are good and do demonstrate the points in question; the line drawings of operative steps are clear, and the coloured plates are excellent. The proof reading has been careful and we could find no typographical errors.

This book, while of special interest to the orthopædic surgeon, will appeal especially to general surgeons and practitioners whose work is not so sharply circumscribed. It should prove invaluable in military practice.

The Synovial Membrane and the Synovial Fluid with Special Reference to Arthritis and Injuries of the Joints. By DAVID H. KLING, M.D., Assistant Professor of Orthopedic Surgery and Chief of Arthritis Clinic, White Memorial Hospital, Los Angeles, California. 9¼ × 6 in. Pp. 283, with 80 illustrations and 34 tables. 1939. London: Baillière, Tindall & Cox. 25s. net.

ALTHOUGH the gross structure of joints has engaged the attention of anatomists and surgeons for centuries, interest in the synovial membrane and the fluid it secretes is a recent development. But during the last thirty years an immense amount of valuable work has been done,

and Dr. D. H. Kling has had the wisdom and industry to collect and present it in an orderly fashion in his book *The Synovial Membrane and the Synovial Fluid.* To this subject Dr. Kling has made a number of important contributions, yet they are presented so modestly and in such natural relation with the work of others that the book is not spoiled by any personal bias. He is satisfied that the synovial membrane is a properly differentiated structure and not merely a mesodermal surface produced in response to a particular mechanical environment.

Synovial membrane is a good material for histological study, and its vital properties, particularly its connection with the lymphatic system, are well shown by animal experiments—some of which are applicable to man. Dr. Kling deals with synovial fluid in much the same way as others have described the properties of cerebrospinal fluid—and the conclusions, particularly where pathological conditions are under consideration, are in a sense similar. That is to say, the synovial fluid gives valuable information about diseases we understand fairly completely, such as pyogenic and tuberculous arthritis, but lamentably little about the many forms of arthritis that still puzzle us. Perhaps the most melancholy feature of all this work so well described in this book is that examination of the tissues chiefly involved has shed so little light on the nature of a group of diseases so widespread and so devastating. Nevertheless the section on special pathology should prove of great value to clinicians and pathologists who are interested in joint diseases, and from the purely practical point of view it is an excellent guide to laboratory work.

It is a little disappointing to find few references to the function of synovial fluid as a lubricant, and one hopes that Dr. Kling will have an opportunity to remedy this defect in a later edition. Surgeons in this country have been introduced to this aspect of joint function by M. A. MacConaill of Sheffield, and its interest is not merely academic. There are misprints here and there, and a few figures are so indistinct as to be valueless, but these are minor blemishes in an otherwise excellent contribution to our literature.

El Pie Talo poliomielítico y su Tratamiento. Study of 170 Cases. By Dr. VICENTE SANCHIS OLMOS. 8 × 5½ in. Pp. 142, with 59 illustrations. 1940. Madrid: Espasa-Calpe, S.A. 10 pesetas.

THIS little monograph was originally a thesis for the Doctorate in the University of Bologna, where the author worked under Putti, who put the material of the Rizzoli Institute at his disposal. Talipes calcaneus is an imperfectly solved problem, and any study, mathematical, pathological, or clinical, that contributes to the betterment of treatment is welcome. The relations of the axes of the tarsal bones to one another and to the incident stresses on the foot as a whole are worth careful investigation.

The author, on the whole, favours Putti's method of preventing dorsiflexion of the foot by a peg-graft into the astragalus immediately in front of the tibial epiphysis, or by a transplant of bone from the dorsal aspect of the head beneath the anterior part of the upper articular surface of the astragalus. Combined with cuneiform osteotomies or arthrodesis, this method gives a stable plantigrade foot, and the results seem satisfactory. Clinical histories of a hundred and sixty cases are appended.

Surgery of the Hand. Some Practical Aspects. By JOHN HAROLD COUCH, M.A., M.B., F.R.C.S. (Edin.), Department of Surgery, University of Toronto and Toronto General Hospital. With a Foreword by W. E. GALLIE, M.D., F.R.C.S. (Eng.), Dean of the Faculty of Medicine, University of Toronto. 8⅛ × 5¼ in. Pp. 147 + ix, with 29 illustrations. 1939. Toronto: The University of Toronto Press. (London: Humphrey Milford.)

PROFESSOR GALLIE, who writes a preface, explains that for ten years Mr. Couch has been entrusted with all the hand surgery of the Toronto General Hospital, and expresses the opinion that this kind of narrow specialism gives good practical results.

The book is marked by brevity, simplicity, and dogmatism. Careful excision of the wound with absence of antiseptics, the suture of nerves and tendons, the best site for amputation, and the various problems of infection are described shortly and clearly. The illustrations are clear and instructive.

Relation of Trauma to New Growths. Medico-legal Aspects. By R. J. BEHAN, M.D., F.A.C.S. 9½ × 6 in. Pp. 425 + xii. 1939. London: Baillière, Tindall & Cox. 22s. 6d. net.

THE author of this book has made himself conversant with the vast array of cases reported in the medical literature of the United States and Germany which have a medico-legal bearing on this very vexed question of the relationship of injury to new growth. As he practices in America (Pittsburgh Hospital) and has taken a medical degree in Berlin, he has become personally familiar with the scientific and legal opinions of these two countries. He mentions that between the years 1882 and 1897 there appeared over three thousand books and papers on the subject, of which the majority were in German. And yet this subject seems more doubtful and debatable than ever! So long as we know neither the exact nature of a malignant growth nor its cause, it is impossible to do more than conjecture as to its origin.

As years go by, however, there is an ever accumulating number of cases in which the Law Courts hold that injury has been the direct or indirect cause of cancer. In order to establish a probability of this relationship four postulates should be established—namely: (1) The certain proof of the injury; (2) The occurrence of the growth at the site of the injury; (3) The severity of the injury should be capable of producing changes in the tissues; and (4) A suitable time relationship, that is, the swelling should occur shortly after the injury, or a trail of symptoms should connect the two.

A long discussion is devoted to this question of the time factor, but at the outset we are confused by apparently contradictory statements. To begin with, it is stated without any equivocation that the latent period in man is as a rule 15 to 20 years, but in the pages which follow, this rule is repeatedly contradicted and we are told that for sarcoma the period varies from 8 days to 2 years and for carcinoma from 3 weeks to 3 years. However, the great value of the book is the careful compilation of a large number and wide variety of medico-legal cases, illustrating the various Court decisions which have been given from time to time. The various conditions of occupational cancer are described (aniline-workers' cancer of the bladder, chimney-sweep's cancer of the scrotum, mule-spinner's cancer, cancer derived from arsenic and radiation).

Twelve chapters are devoted to a description of the various tumours arising in different sites and in different tissues as they appear to have any causative relation to trauma. One very interesting section deals with the determination of metastatic growths in the site of an injury. There is some confusion in the description of Ewing's sarcoma, which is described as though it were identical with multiple myelomata.

The book will be of much use in giving a reference to German and American literature for the benefit of the English reader.

Sclerosing Therapy. The Injection Treatment of Hernia, Hydrocele, Varicose Veins and Hæmorrhoids. Edited by FRANK C. YEOMANS, M.D., F.A.C.S., Professor of Proctology and Attending Surgeon, New York Polyclinic Medical School and Hospital. 10 × 7 in. Pp. 337 + xii, with 117 illustrations. 1939. London: Ballière, Tindall & Cox. 27s. net.

HOMAGE to Pravaz appears to have suggested the scope of this book, which reviews, in four sections by various authors, the present state of our knowledge and experience of the injection treatment for hernia, hydrocele, varicose veins, and hæmorrhoids.

The first section deals with a controversial method which has probably been tested by far less objective investigation in this country than in America, and Dr. Bratrud presents an unbiased survey of the merits and dangers of the method; a lucid description of the technique, stressing the importance after injection of a well-fitted truss, of which the protean modifications illustrated put to shame the less imaginative aspirations of the English appliance maker; and in conclusion an interesting chapter upon the legal aspects of herniæ.

It is apparent that injection and operative treatment are not supplementary, as the most satisfactory results from the former occur in the group of recent indirect inguinal herniæ in young patients, a group in which the results of herniotomy are equally satisfactory, and the contra-indications are approximately the same for the two methods. The recurrence rate after injection therapy observed in a series of 686 cases treated in the Clinic for Ambulant Treatment of Hernia at the University of Minnesota Medical School was 24 per cent in indirect inguinal herniæ, 28 per cent in bilateral indirect, 40 per cent in direct, and 55 per cent in femoral herniæ, figures which certainly show no improvement upon the results of herniotomy.

The remaining sections of the book, by Drs. Hoch, Shelley, and Yeomans, are all excellent, especially the comprehensive survey of varicose veins and their treatment; the views expressed by these authors are conventional and are in agreement with those held by the majority of surgeons in this country.

A Descriptive Atlas of Radiographs. An Aid to Modern Clinical Methods. By A. P. BERTWISTLE, M.B., Ch.B., F.R.C.S. Ed. Fourth edition, revised and enlarged. 9¾ × 7¼ in. Pp. 576 + xxxii, with 852 illustrations. 1939. London: Henry Kimpton. 42s. net.

THE first edition of this book was published in 1926, and it has been kept well up to date by fresh editions every few years.

Radiography has been extending so rapidly during the past decade that it is almost impossible for anyone to be familiar with all its recent developments. Dr. Bertwistle has shown considerable judgement in selecting his illustrations, so that for a book of moderate dimensions it gives a wide view of the whole subject, both of normal and abnormal conditions. Mr. Jocelyn Swan has revised the section on the urinary system and Dr. Ramage that on the respiratory system.

Fisiopatologia del Hepato-colédoco. Colangiographia operatoria. By PABLO L. MIRIZZI, Professor Titular de Clínica quirúrgica de la Facultad de Medicina de Córdoba. 10½ × 7 in. Pp. 282, with 190 illustrations. 1939. Buenos Aires: El Ateneo.

THIS remarkable volume, quite an outstanding piece of book production, describes and illustrates very lavishly the author's method of investigating the state of the biliary tract during operations by injecting lipiodol into the cystic or common ducts. A lot of work has been done in South America on obstruction at the sphincter of Oddi and at other points in the tract, some dependent on spasm and some on organic narrowing, the result generally of antecedent or persisting cholangeitis. There must often be moments in any surgeon's practice when he terminates an operation a little uncertain of the perfect permeability of the tract, and uninformed as to the effect of back-pressure upon the hepatic, intrahepatic, or pancreatic ducts. Here is described a method which the author says is harmless and rapid, by which the operator can assure himself of the state of affairs, can assess the need for further intervention on the duct, or for short circuit, and can estimate the chances of recovery or further trouble. Certainly the many excellent radiographs reproduced witness the precision of the information supplied and add to existing knowledge of the effects of disease in the bile-passages.

Localisations viscérales et Aspects chirurgicaux des Brucelloses. By R. MICHEL-BECHET, with the collaboration of R. PUIG and P. CHARVET. With an Introduction by B. CUNÉO. 9¾ × 6¼ in. Pp. 168, with 22 illustrations. 1939. Paris: Masson et Cie. 4s. 6d. net.

THIS monograph should be of interest to clinicians in this country at the present time, when infections due to organisms of the brucella group are being increasingly recognized as a cause of hitherto obscure complaints. In this country the responsible organism is invariably the *Brucella abortus* of Bang, which is found extensively in cattle, and is excreted in their milk. In France the prevalent strain is *Brucella melitensis*, though *Brucella abortus* is found to be responsible for about 6 per cent of the infections observed by the authors of this monograph. They state, however, that there are no important clinical differences in the nature of the lesions produced by these two strains in the human body. In their experience the great majority of cases were infected by direct contact with diseased animals, and in only a minority was the disease conveyed by milk; but here it must be recalled that raw milk is rarely drunk in France. The possibility of brucella infections should therefore always be borne in mind when dealing with patients who are herdsmen, slaughterers, or butchers.

The writers point out that since the infection in its early stages is a true bacteriæmia, localized lesions may be found anywhere in the body. Beyond stating that the heart, kidneys, and blood-vessels are rarely affected, they give no indication of the relative frequency of the various lesions they describe. In 80 per cent of their cases showing a localized lesion, its appearance had been preceded by a generalized infection and the diagnosis had already been

made. They noted that the apyrexial cases, which may easily be overlooked, occurred most commonly in children.

In their account of the lesions likely to be encountered by surgeons, the authors repeatedly emphasize the need for the surgeon to be able to make the diagnosis. Orchitis is a very frequent manifestation, but it is usually mild, clears up completely, and does not appear to inflict any permanent damage on the testis. Of particular interest are the lesions of bones and joints. In the long bones anything may occur from a transient osteitis to a true osteomyelitis with abscess formation. Sequestration is rare and the milder cases often show an unusual degree of periosteal involvement. Arthritis may be acute or chronic; it is monarticular, and the hip-joint is most frequently involved. The prognosis is good, but stiffness may result in joints immobilized for long periods. In the care of the hip brucella infection may easily be mistaken for tuberculosis, though there is rarely complete loss of movement and the regional lymph-glands are never involved.

The spine may be affected, and radiographs often show a *pincement* of one disc indistinguishable from early Pott's disease. The shadow of an abscess may also be present. In other cases pain and the presence of a localized rarefaction of one vertebra may suggest chronic pyogenic osteomyelitis, but the destruction is rarely extensive enough to cause collapse of the bone.

On the whole the disease has a good prognosis and the various lesions usually clear up with rest. Surgical interference is rarely called for; when an abscess appears drainage may be necessary. At present there is no specific treatment.

If the possibility of the occurrence of the disease is constantly borne in mind, the diagnosis can readily be made by means of the agglutination reactions, and the organism may be found in pus if appropriate cultures are made.

The monograph is clearly written, but it is a pity that no figures are given to show the relative frequency of the various lesions described, and there is a complete absence of detailed reference to the writings of other workers.

Illustrations of Surgical Treatment, Instruments and Appliances. By ERIC L. FARQUHARSON, M.D., F.R.C.S.E., Tutor in Clinical Surgery, Royal Infirmary of Edinburgh. With a Foreword by Sir JOHN FRASER, *M.C.*, M.D., Ch.M., F.R.C.S.E., Regius Professor of Clinical Surgery, University of Edinburgh. 9½ × 6 in. Pp. 338 + xii, with 259 illustrations and 57 plates of collections of instruments. 1939. Edinburgh: E. & S. Livingstone. 20s. net.

THE title of the volume under review is rather misleading, and gives little indication that the branches of surgery dealt with consist only of fractures and orthopædics, with short chapters on infusions and transfusions. The text of the book is in two sections. The first section consists essentially of a series of illustrations, with accompanying notes on practical details, demonstrating methods used in the treatment of fractures and certain bone and joint lesions. The illustrations are instructive, but fundamental principles are subordinate to practical details, and alternative methods of treatment are not given equal prominence in certain instances where, as yet, there exists no unanimity of opinion concerning the most successful method. This section of the book will be of most help to the house-surgeon who has developed to some extent his critical faculties, and the post-graduate student.

The second section, comprising a series of illustrations of surgical instruments, many of which have already been relegated to the limbo of the museum, will possibly be of help to the student on the eve of his surgical viva-voce examination at a Scottish university.

A Mirror for Surgeons. Selected Readings in Surgery. By Sir D'ARCY POWER, K.B.E., F.R.C.S., Consulting Surgeon to and Archivist at St. Bartholomew's Hospital, London, 8 × 5½ in. Pp. 230 + xii. 1939. Boston: Little, Brown & Co.

A Mirror for Magistrates was an account of the vices and downfall of illustrious men, but Sir d'Arcy Power's *Mirror for Surgeons* is a reflection of the great names in English-speaking surgery (it is true that the Frenchman Ambroise Paré is included, but Thomas Johnson translated him into good English). It is a pleasant book to brouse in, consisting of extracts from the writings of twenty-two surgeons from John J. Arderne to Sir William Macewen, each with a thumbnail biography in Sir d'Arcy's elegant style. Three of the great names

in American surgery—Halstead, Bigelow, and Sims—are included, and no doubt Harvey Cushing will join their ranks in the next edition.

Ten years ago, when Sir d'Arcy Power's seventy-fifth birthday was celebrated by presenting him with a volume of his selected writings, the number of his published works was over six hundred, and as Sir d'Arcy's pen has been by no means idle in the interval, it is quite possible that he will achieve the millenary in the very near future.

A Mirror for Surgeons will prove a delightful bedside book and is of that dumpy size which is comfortable for bed reading, no matter what posture one favours.

Hospital for the Ruptured and Crippled. A Historical Sketch written on the occasion of the Seventy-fifth Anniversary of the Hospital. By FENWICK BEEKMAN, M.D. With a Foreword by PHILIP D. WILSON, Surgeon-in-Chief. 9 × 6 in. Pp. 157, with Frontispiece and 10 Plates. 1939. Printed privately in New York (copies from Superintendent). $3.00.

IT is well that the histories of our hospitals should be written, and written by experts. So it is well that the history of the Hospital for the Ruptured and Crippled in New York should now come from the pen of a skilled medical historian and biographer, Dr. Beekman, to mark its seventy-fifth anniversary. This sketch is of value, for not only does it trace the fortunes of this hospital, but it records the development of orthopædic surgery in the United States and the work of some famous pioneers.

Dr. James Knight established himself at the age of 25 as a general practitioner in New York. His work as a Visitor for the Association for the Improvement of the Poor brought him into contact with persons unable to work on account of their physical infirmities and deformities. So impressed was he with the need of some special provision for their relief, that he made earnest efforts to establish some institution for the purpose. These efforts resulted in the foundation of the hospital in 1863, of which he became the first surgeon-in-chief.

The hospital started modestly in the house of Dr. Knight, whose conservatory had been fitted up as a workshop to make surgical appliances for the patients. This house soon proving inadequate, a good hospital was built in 1870 and was occupied until 1912, when it was again removed to its present site.

After Knight came Dr. Virgil P. Gibney, the pupil of Lewis A. Sayre, who introduced the method of suspension in a plaster jacket for Pott's disease of the spine. To Dr. Gibney the credit should be given, it would seem, for ensuring that the work of the hospital ran on progressive lines. He visited the best clinics in England and Europe: he learnt to appreciate the antiseptic principles of Lister: he became the friend of Thomas, of Liverpool, and of Robert Jones, his nephew, and he carried back with him the lessons he had learnt.

One cannot enumerate the names of all the men who contributed to the fame of the hospital and did faithful work for the patients. It is necessary, though, to mention two famous men—Royal Whitman and William B. Coley. Both these men were on the staff of the hospital; both established for themselves world-wide reputations which have been recognized by the conferment on them of the Honorary Fellowship of the Royal College of Surgeons of England. It is interesting now for an onlooker to discuss how it should come about that a hospital with the uninspiring title "For the Ruptured and Crippled" has brought itself to the forefront of surgery. The reason is not hard to seek—those responsible for the direction of the hospital did not allow themselves to be divorced from the principles of medicine and surgery; they did not become narrow specialists relying only on mechanical means of treatment, on crutches, trusses, and irons. The hospital has been happy in its staff.

The Macewen Outlook in Surgery. The Macewen Memorial Lecture, 1939. By G. GREY TURNER, D.Ch. (Hon.), M.S., F.R.C.S., F.A.C.S. (Hon.), F.R.A.C.S. (Hon.), Professor of Surgery in the University of London; Director of the Department of Surgery, British Postgraduate Medical School. 8½ × 5½ in. Pp. 72, with Frontispiece and 15 illustrations. 1939. Glasgow: Jackson, Son & Co.

PROFESSOR GREY TURNER rightly points out that although Macewen was among us until 1924 there is already a generation of surgeons to whom he is only a name, albeit a legendary one. In the course of the lecture many personal memories of Macewen are interestingly

brought out. Grey Turner discusses many of his early surgical experiences and those of his immediate chief, and points out the influence of what the lecturer terms the "Macewen outlook". The book contains fifteen illustrations, at least two of which are historic. It will no doubt achieve its purpose, namely, to honour the name of one of the master surgeons of recent years.

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.*]

Theory and Treatment of Fractures of the Jaws in Peace and War. By HORACE HAYMAN BOYLE, H.D.D. and L.D.S. (R.F.P.S.) Glas., H.D.D. (R.C.S.) Edin., late Captain, D, Army Medical Service; Dental Surgeon to the Ministry of Pensions; etc. 9¾ × 6 in. Pp. 288, with 127 illustrations. 1940. London: Henry Kimpton. 21s. net.

Patogenia de la Hidatidosis bi-epifisaria de las Articulaciones (Intervencion de los Ligamentos intra-articulares). By P. LARGHERO YBARZ, Professor of Pathological Surgery of the Faculty of Medicine, Montevideo. 9⅝ × 6¾ in. Pp. 77, with numerous illustrations. 1939. Montevideo: A. Monteverde.

Cancer in Childhood. And a Discussion of Certain Benign Tumors. Edited by HAROLD W. DARGEON, M.D., F.A.A.P., Attending Pediatrician, Memorial Hospital for Cancer and Allied Diseases, New York; etc. 10 × 6½ in. Pp. 114, with numerous illustrations. 1940. London: Henry Kimpton. 15s. net.

Hæmorrhoids and Their Treatment. The Varicose Syndrome of the Rectum. By KASPER BLOND, M.D., Vienna. Translated by E. STANLEY LEE, M.S., F.R.C.S., Hon. Assistant Surgeon, Westminster Hospital. 8⅞ × 5⅝ in. Pp. 140 + viii, with 49 illustrations, several in colour. 1940. Bristol: John Wright & Sons Ltd. 15s. net.

Tomography. By J. B. MCDOUGALL, M.D. (Glas.), F.R.C.P. (Edin.), F.R.S.E., F.R.F.P. & S. Glas., Adviser in Respiratory Diseases to the British Legion; Medical Director, Preston Hall, Maidstone, Kent; Medical Superintendent, Douglas House, Bournemouth. 11 × 8½ in. Pp. 73, with 110 illustrations. 1940. London: H. K. Lewis & Co. Ltd. 21s. net.

St. Thomas's Hospital Reports. Edited by Professor O. L. V. S. De WESSELOW and C. MAX PAGE, assisted by N. R. BARRETT, J. ST. C. ELKINGTON, and A. J. WRIGLEY. Second Series. Vol. IV. Royal 8vo. Pp. 198, illustrated. St. Thomas's Hospital. 10s. (7s. 6d. to St. Thomas's men).

The Christie Hospital and Holt Radium Institute, Manchester. Statistical Report on the Results of Radium Therapy in the Treatment of Malignant Disease. Analysis of the Work of the Institute for the Years 1932 and 1933 assessed at 5 years. 8¾ × 6 in. Pp. 100. 1940. Copies obtainable from Dr. Ralston Paterson, Director, Holt Radium Institute.

Cyclopropane Anæsthesia. By BENJAMIN HOWARD ROBBINS, B.A., M.S., M.D., Associate Professor of Pharmacology, Vanderbilt University School of Medicine. 9 × 6 in. Pp. 175 + xii, with 40 illustrations. 1940. Baltimore: Williams & Wilkins Co. (London: Baillière, Tindall & Cox.) 16s. 6d. net.

La Thoracoplastie élective. Primitive, d'Association, de Substitution. By J. ANGIRANY, L. MICHON, and A. DE MICHEAUX. With a Preface by F. DUMAREST. 9⅝ × 6⅝ in. Pp. 128 + x, with 28 plates. 1940. Paris: Masson et Cie. $1.35.

Surgery of the Hand. Wounds, Infections and Closed Traumata. A Book for the Practitioner and the Student. By MARC ISELIN, M.D., Surgeon, The American Hospital, Paris. Translated by T. M. J. d'OFFAY, M.B., Ch.B. (Edin.), F.R.C.S. Eng., Surgeon and Deputy Medical Superintendent, City General Hospital, Leicester; and THOMAS B. MOUAT, M.D., Ch.M. (Edin.), F.R.C.S. Eng., Surgeon, The Royal Infirmary, Sheffield, Lecturer in Surgery, The University of Sheffield. 8¾ × 5½ in. Pp. 353 + xiv, with 135 illustrations. 1940. London: J. & A. Churchill Ltd. 21s. net.

Traité de la Transfusion sanguine. By G. JEANNENERY and G. RINGENBACH, Bordeaux. 9¾ × 6½ in. Pp. 386 + viii, with 112 illustrations. 1940. Paris: Masson et Cie. $2.50.

Synopsis of Operative Surgery. By H. E. MOBLEY, M.D., F.A.C.S., Chief of Surgery at St. Anthony's Hospital, Morrilton, Arkansas. 8⅛ × 5 in. Pp. 375, with 339 illustrations, of which 39 are in colour. 1940. London: Henry Kimpton. 21s. net.

Common Mistakes of Surgery in India and How to Avoid These. By Lieut.-Col. A. N. PALIT, O.B.E., F.R.C.S. Edin., M.R.C.O.G., I.M.S. (Rtd.), Senior Surgeon, Chittaranjan Seva Sadan Hospital, Calcutta. 7⅝ × 5⅜ in. Pp. 382 + xix, illustrated. 1940. Calcutta: The Book Co. Ltd. 8s. 6d. net.

Surgical Anatomy. By GRANT MASSIE, M.B., M.S. (Lond.), F.R.C.S. (Eng.), Surgeon, Guy's Hospital; Lecturer on Operative Surgery, Guy's Hospital Medical School. Fourth edition. 9¼ × 6 in. Pp. 472 + viii, with 158 illustrations. 1940. London: J. & A. Churchill Ltd. 21s. net.

Diseases of the Urethra and Penis. By E. D'ARCY MCCREA, M.D., M.CH. (Dub.), F.R.C.S.I., F.R.C.S. (Eng.), Hon. Surgeon at Salford Royal Hospital, Manchester. 8⅞ × 6 in. Pp. 306 + viii, with 181 illustrations, some in colour. 1940. Bristol: John Wright & Sons Ltd. 21s. net.

Operative Surgery. By J. SHELTON HORSLEY, M.D., LL.D., F.A.C.S., Attending Surgeon, St. Elizabeth's Hospital, Richmond, Va., and ISAAC A. BIGGER, M.D., Professor of Surgery, Medical College of Virginia; Surgeon-in-Chief, Medical College of Virginia Hospitals, Richmond, Va. With contributions by C. C. COLEMAN, M.D., F.A.C.S., AUSTIN I. DODSON, M.D., F.A.C.S., JOHN S. HORSLEY, jun., M.D., and DONALD N. FAULKNER, M.D. In two volumes. Fifth edition. 10 × 6⅝ in. Pp. 1567 + xxvi, with 1391 illustrations. 1940. London: Henry Kimpton. 90s. net.

Berkeley Moynihan, Surgeon. By DONALD BATEMAN. 8½ × 5½ in. Pp. 355 + xv, with 8 illustrations. 1940. London: Macmillan & Co., Ltd. 12s. 6d. net.